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Vol. 133, No. 3469

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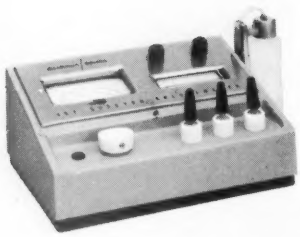

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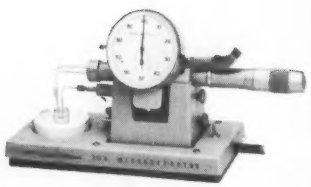

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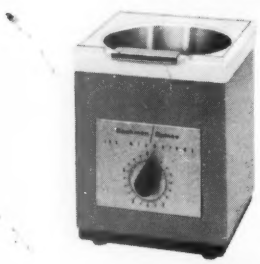

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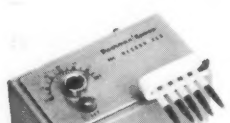

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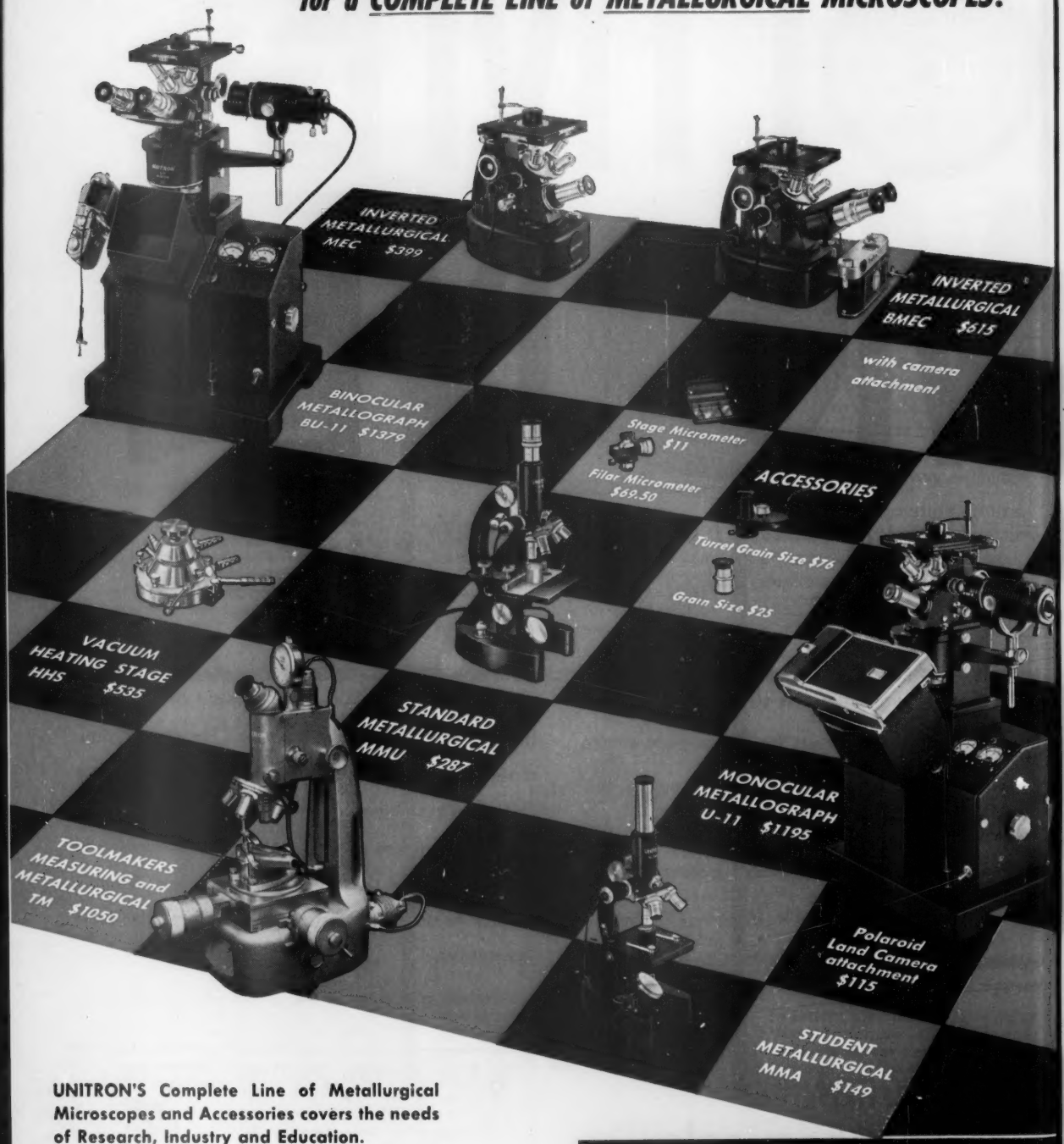

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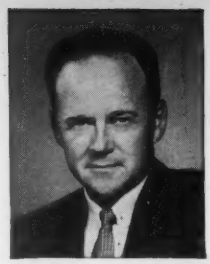

The Nature of Oxidation: Studies In The High-Temperature Oxidation of Alloys

Under high temperatures, oxidation is accelerated. While some pure metals deteriorate rapidly, certain of their alloys oxidize much more slowly. Accurate prediction of alloy oxidation rates, however, awaits development of a reliable mathematical model. At Honeywell Research, new techniques have produced data that make a start toward a universally applicable theory.

With the single exception of gold, oxidation limits the use of all metals at high temperatures. This is true because the products of corrosion do not have the properties of the parent metal. In addition, corrosive products occupy more space than the parent metal they replace, affecting dimensions and tolerances.

Corrosion is greatly accelerated by high temperatures, putting serious limitations on progress in heat generating equipment such as internal combustion engines, rockets, nuclear reactors and electrical contacts.

At the present time the accepted method of inhibiting corrosion is to apply a protective coating to the metal to prevent the migration of oxygen atoms to the surface of the material. This, however, is expensive and in many cases not practical.

We know that when an oxide free surface is exposed to ordinary air at room temperature the upper layers of the metal combine with the oxygen atoms to form a thin film or scale (oxide). For further oxidation to occur the thin oxide film must be penetrated by either oxygen atoms migrating down to the fresh metal surface or by metal atoms migrating outward to the air. In most cases, one of these reactions predominates.

For about 40 years metallurgists have worked with several classical equations that predict the rate of oxidation. However, these equations apply rigorously only under idealized conditions. They do not fully equate the mechanical and microstructural features of a multi-layer oxide or the dislocations and stresses that affect the oxidation process. For example: Is the oxide film ductile or brittle? A change of temperature puts thermal stress on the oxide and if it is brittle it will probably break off. These properties modify the classical theory. All of these problems multiply and each influence is changed when an alloy is introduced.

Honeywell scientists hope to learn more about these altering influences in order to extend the classical equations. They are analyzing multi-layer oxide scales with a number of different laboratory methods to build support for new, predictable behavior.

Multi-layer scales are caused by the ability of metals to have multiple valences. The balance between these layers is controlled by temperature. When a multi-layer scale exists, oxides are often unable to relax the stresses that occur. These stresses are caused by the differences in specific volume and the differences in thermal coefficients of expansion between the oxide and the metal. When they cannot be relaxed, stresses may build up and affect the rate of oxidation. Also, if external stresses are applied to the material the rate of oxidation may be affected.

The approach to this study quickly becomes a mixture of metallurgy and physical chemistry. One technique in studying rate of growth of the scale has been to measure the weight gain of alloys during oxidation. Reliable data on oxidation has been obtained in this manner.

To determine the direction of the migration of ions and also measure the growth of individual layers, Honeywell scientists are welding thin platinum wires to a specimen prior to heating. These marker wires give a point of reference to the original surface. If oxygen ions are moving inward, the wire remains outside the surface. If cations are moving outward, the marker wire will be under the surface. This method has yielded valuable new information on the formation of oxides.

Microscopic examination also has been helpful in identifying layers, and X-ray diffraction has given positive identification of the oxide phases.

Ideally we would like to completely inhibit even the first monatomic oxide layer. At the present state of knowledge, this seems unattainable. Our approach then is to utilize the natural oxidation process but control it. By doing this we permit the formation of a thin film but seek to make it impermeable to further ion migration.

In our experiments Honeywell scientists have effected radical changes in oxidation rates by changing the oxide microstructure through heat treatment of its alloy. For example, with an alloy of .87 Mg—.62 Cu, the oxidation rate can be retarded and the resulting oxidation reduced by a factor of ten with proper heat treatment.

We now know that in a polycrystalline structure, stress and mechanical properties affect both the rate and the mechanism of oxidation. Also we know that the mechanical properties of the oxide have a decisive effect on the tendency of the oxide to either spall or adhere.

This is a start toward the derivation of a general theory explaining the oxidation of alloys. Though our research is basic at this point in time, we expect it to yield many practical answers to assist the design engineers working on high temperature problems confronting today's nuclear and space projects.

If you are engaged in scientific work relating to oxidation of metals and would like to know more about Honeywell's research on this subject, you are invited to correspond with Dr. J. A. Sartell, Honeywell Research Center, Hopkins, Minnesota.

If you wish a recent paper, "The Role of Oxide Plasticity in the Oxidation Mechanism of Pure Copper," by Dr. Sartell, write to Honeywell Research, Minneapolis 8, Minnesota.

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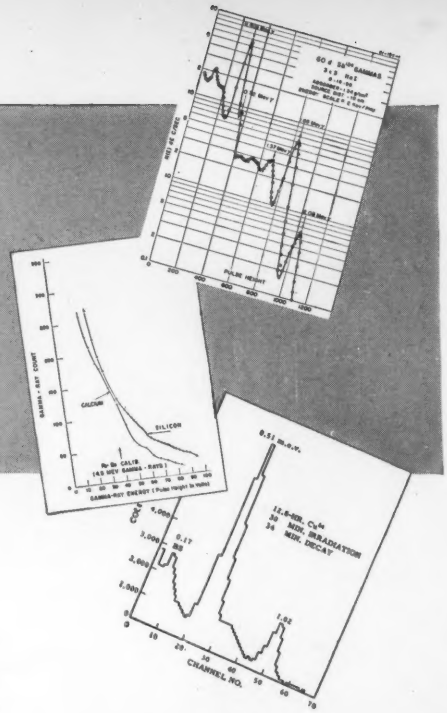

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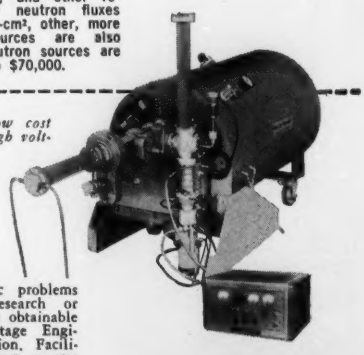

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How To Let Go and Still Hold the Line

Although the demand for mathematics teachers with Ph.D.'s has greatly increased in recent years, the supply, contrary to the familiar economic law, has been diminishing. Enrollment in mathematics courses is growing much faster than total enrollment in college, with the greatest growth in advanced courses. At the same time, although the number of new Ph.D.'s turned out each year has also grown, with so many mathematicians going into government or industry, the number becoming teachers is not even enough to balance annual losses. This surprising situation was reported by Edwin Moise, of Harvard University, in the April issue of the American Mathematical Society's *Notices*. Moise was speaking for a special committee of mathematicians. What is also surprising is that the committee goes on to suggest that the remedy does not necessarily lie in redoing the entire value structure of American society, but in redoing some of the values entertained by the mathematical community.

To get a doctorate in mathematics, the candidate must now pass preliminary examinations and then write a dissertation offering some new and interesting mathematical proofs. The idea behind this procedure is that to teach mathematics you have to be a creative mathematician yourself. The committee questions this assumption. It suggests an alternative program of study in which the creative dissertation is replaced by "a scholarly dissertation which could be historical, critical, or philosophical," with history understood to include very recent history. Such research, it is claimed, would also be sensible preparation for effective teaching and would result in something of value to the mathematical community. To distinguish the new program from the traditional one, there would also be a new graduate degree in mathematics, the Doctor of Arts.

Official groups of the American Mathematical Society and of the Mathematical Association of America have approved these sentiments in principle, but not all mathematicians are so happy about the proposal. Some criticisms are expressed in a letter to the editor in the June issue of the *Notices*. One criticism is that there has not really been a study of why, with B.A.'s in mathematics comparatively plentiful, Ph.D.'s are so scarce, and that such a study might well show that the hurdle is not the dissertation but the preliminary examinations. A second criticism is that the introduction of a new program of study would mean the introduction of class distinctions among mathematicians, with the upper and lower classes regarding each other with condescension on the one side and envy on the other.

The proposal does have a certain appeal, however. In another field, no necessary connection is expected between being a good novelist and being a good teacher of literature. A key question about the proposal is whether its proponents really mean it when they say that the new kind of dissertation would be both preparation for teaching and a contribution to scholarship. If so, then why not accept the new dissertation but drop the idea of a new "Doctor of Arts" degree, and let the Ph.D. degree serve here as well? The number of additional teachers that would result is not known, but the idea would then seem quite worth pursuing. Differences in status we will always have with us. There are differences now regarding universities, supervisory professors, and dissertation topics. But neither these differences nor those between creative and scholarly work need be shouted from roof tops to be appreciated.—J.T.

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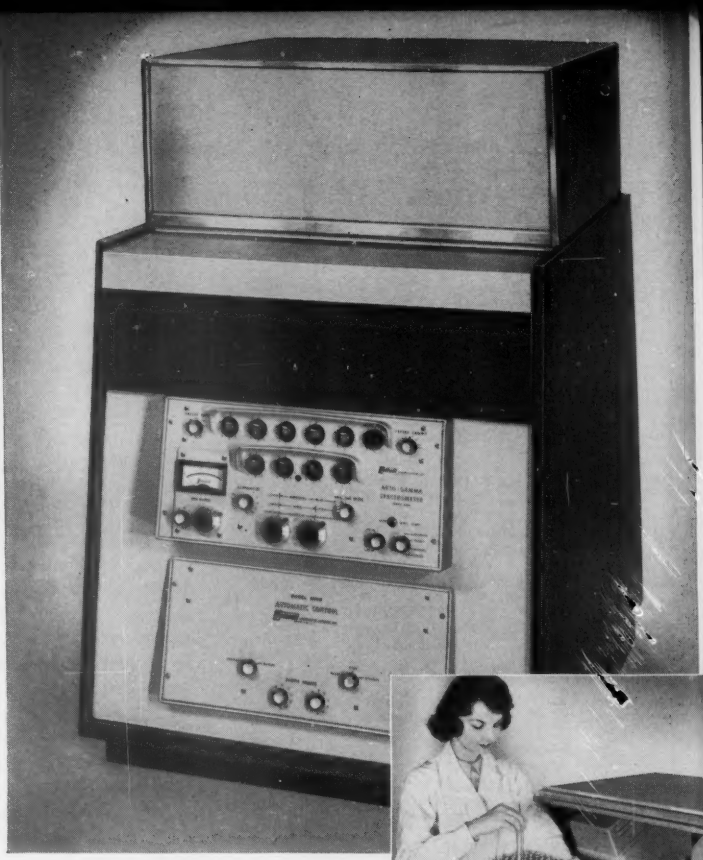

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23 June 1961, Volume 133, Number 3469 SCIENCE

Reorganization of Science and Research in the U.S.S.R.

A new top-level government committee will coordinate interdisciplinary basic and applied research.

Nicholas DeWitt

On 12 April 1961, while the world was caught up in the excitement of the Soviet cosmonaut, *Pravda* published a major decree of the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the U.S.S.R., entitled "Concerning Measures To Improve the Coordination of Research and Development Work in the Country and the Activities of the Academy of Sciences of the USSR." This official decree, first disclosed at a meeting of the Academy of Sciences on 10 April, resolved, finally, the protracted institutional debate which had raged since the mid-1950's concerning the management of the Soviet Union's burgeoning research and development effort, a debate overshadowed by Soviet technological spectaculars.

Some observers have looked upon the Soviet scientific organization as a carefully charted administrative pyramid with a well-developed decision-making mechanism. In some strategic areas of research, the Soviet principle of centralized decision-making has indeed been often and easily translated into the mobilization of human and material resources for the attainment of given objectives. Without separating civilian or military, political or scientific, objectives, once a decision was reached, the planning mechanism set in motion the priorities to allocate the human and physical resources from different institutions and from diverse jurisdictions and localities. This was not true, however, of all areas of Soviet research and development. The current decree of the Soviet government and Communist Party forcefully pointed up the problem: "The presence at the Academy of Sciences of the USSR of a large number of specialized research institutions diverts its attention from the long-run basic problems of science, splinters its work force and material resources on many technical problems of a departmental nature, which can be handled successfully in specialized research and development institutes. These shortcomings in the work of the Academy and in other research and development organizations are largely a result of the absence in the country of a single governmental unit which could coordinate research on a national scale. The absence of such a unit in many cases has led to unjustifiable duplications in research and the irrational use of scientific personnel and material resources" (*1*).

While this problem has existed in the past, it is the recent expansion of the Soviet research establishment which has brought it most clearly to the fore.

The author is research associate, Office of Scientific Personnel, National Academy of Sciences–National Research Council, Washington, D.C., and associate, Russian Research Center, Harvard University, Cambridge, Mass.

Growth of the Soviet Research Establishment

Table 1 provides data (*2*) on professional higher-education graduates and on research and academic personnel engaged in the Soviet economy in general, and in the research establishment proper. During the last two decades, while the total nonagricultural employment of workers and salaried employees about doubled in the U.S.S.R., the over-all number of professionals and of research and academic personnel increased about four times. If we consider employment in the Soviet research establishment only, however, the number of professional graduates of institutions of higher education and of researchers increased at rates substantially higher—five and eight times, respectively.

What is particularly important, however, is that the most rapid growth of the Soviet research establishment has taken place in the last 5 years. Between 1956 and 1961 the total employment, the number of professional graduates, and the number of research and academic personnel engaged in Soviet research establishments has about doubled. This enormous quantitative expansion of the Soviet research establishment has constituted the moving force behind the recent institutional reorganization.

Soviet Research Effort by Field

In the last two decades the dominant emphasis of Soviet research activity has been in the area of the natural sciences. This is shown by the data in Table 2, which indicate that in January 1960 an overwhelming 73 percent of all Soviet research and academic personnel were concentrated in the physical and biological sciences. Within these areas, engineering fields alone accounted for over one-third of all research and academic personnel.

Furthermore, the expansion of the Soviet research establishment in the late 1950's was again most rapid in the

Table 1. Total employment of professional graduates and research personnel in Soviet research establishments, in January of the year indicated (figures in parentheses, index).

Item	Number employed (in thousands)		
	1941	1956	1961
Workers and salaried employees in the national economy (total)	31,500.0 (100)	47,900.0 (155)	62,000.0 (197)
Workers and salaried employees in research and development and science service (total)	361.0 (100)	992.0 (275)	1,732.0 (480)
Workers and salaried employees in research and development only	267.0 (100)	585.0 (220)	1,220.0 (457)
Graduates of professional institutions of higher education employed in the national economy	908.0 (100)	2,340.0 (258)	3,570.0 (394)
Graduates of professional higher-education institutions employed in research and development establishments	91.0 (100)	240.0 (256)	449.0* (494)
Research and academic personnel (total)	98.3 (100)	223.9 (227)	354.2 (361)
Research and academic personnel employed in research and development establishments only	26.4 (100)	96.5 (365)	200.1 (760)
Research institutes			
Total number	1,821	2,797	3,548*
Number of main research institutes	786	1,210	1,608*

* Data as of January 1960.

fields of physical sciences and engineering, as revealed by a comparison of the numerical growth of research and academic personnel by field between 1956 and 1960 (Table 3).

The current trends in training professionals (two-thirds of all graduates of institutions of higher education are in engineering and scientific fields) and research personnel (about three-quarters of them in the natural sciences) indicate that the emphasis in physical sciences and engineering will undoubtedly continue in the 1960's. This quantitative expansion, though achieved at the expense of the humanities and social sciences, has not lowered the quality of scientific or engineering education, which has improved steadily over the years.

The Soviet research establishment today employs a total of 995,000 workers and salaried employees; among them 449,000 are professional graduates, and of these, 188,000 are research personnel. Well over half of the researchers work in the physical sciences or engineering. They are employed in a maze of institutions united under different lines of subordination.

Historical Roots

The Soviet scientific research and development effort is presently an extremely complex and highly organized area of human activity, where external institutional machinery determines to a large degree the vitality of scientific progress. In the last few decades in the Soviet Union, as well as in the rest of the world, the role of the individual scientist as a vehicle of theoretical discovery has remained strong, and in many fields Soviet theoretical and basic research has displayed excellence precisely because the scientist was left to his own devices. In other fields of research, however, individual endeavors gave way to a mass experimentation approach with two notable characteristics: on the one hand, a continuing process of differentiation of fields and ever-increasing specialization within each field, and, on the other, the emergence of the "problem approach," the interpenetration of distinct fields of science in the study of various natural phenomena and the resulting establishment of interdisciplinary fields. It is the latter which requires increasing attention to basic and theoretical research.

Table 2. Soviet research and academic personnel, by field, January 1960.

Field	Number	Percent
Physical sciences		
Engineering	106,960	34.5
Physics-mathematics	24,831	8.0
Chemistry	22,724	7.3
Geology-mineralogy	8,990	2.9
Subtotal	163,505	52.7
Biological sciences		
Biology	13,611	4.4
Agriculture and veterinary science	20,210	6.5
Medicine and pharmaceutical science	31,004	10.0
Subtotal	64,825	20.9
Arts, education, humanities, social sciences		
Philology	19,489	6.3
History and philosophy	17,490	5.6
Pedagogy	13,099	4.2
Economics and planning	12,227	3.9
Art and art history (fine arts, painting, sculpture; music; theater, cinema, and related fields)	4,805	1.6
Architecture	1,339	0.4
Geography	3,890	1.3
Jurisprudence	2,112	0.7
Subtotal	74,451	24.0
Other (unspecified)		
Subtotal	7,241	2.4
Total	310,022	100.0

Ever since the golden age of Russian theoretical science, in the second half of the 19th century, there has been an institutional separation of scientific functions. Russian universities and institutes of higher education concerned themselves with professional education primarily and, to some degree, with broad theoretical research. In addition, however, there was a separate network of scientific research establishments which dealt with experimental research, applied sciences, and highly specialized theoretical investigations. In the latter category there were two types of institutions: (i) the Academy of Sciences, dating back to 1724, under whose auspices a number of specialized institutes were set up, and (ii) a number of independent research institutes, which began to emerge at the turn of the century, serving the applied technological demands of various industries or the research needs of specific fields in medicine, agriculture, and so on. The Soviet regime inherited this institutional setup, in which the bonds between universities and research institutes were loosened long before the Communist Revolution.

Until 1929 all Soviet research and development organizations (except those concerned with military areas) were directly subordinate to the Supreme Council of the National Economy, the highest governmental body in charge of industry, agriculture, and other production activities. It coordinated all research activity. In 1929, Pandora's box was opened, however, when individual research and development institutes were placed under separate departmental auspices in order to intensify their work on practical applications and to identify them more closely with service to individual sectors of industry. In the 1930's the Supreme Council of the National Economy itself was broken up into a variety of administrative departments, called "commissariats" (renamed "ministries" in 1945), each of which took charge of a given sector of industry. Under their auspices, specialized, functional research and development institutes were established and expanded in number and size.

The Academy of Sciences of the

U,S.S.R., since 1933 subordinate to the Council of People's Commissars (later Ministers), was under increased pressure to engage in applied research. In response to this pressure it set up many specialized engineering and technological institutes. In 1935, in order to handle these applied-research tasks, a new Division of Engineering Sciences was added to the Academy's other two divisions—those of natural sciences and mathematics and of the humanities. The Academy was again reorganized in 1938, when the number of its divisions reached eight; and in order to broaden the regional base in scientific research, it was empowered to supervise the regional academies of science set up in the various Soviet republics first as branch offices, then as divisions, and, ultimately, as quasi-independent union-republic academies of science.

It should be noted parenthetically that the Russian word *nauka,* though translated as "science," has the broader connotation of the German *Wissenschaft* and is not limited to the natural sciences; rather, it embraces all fields of human knowledge, and accordingly the Soviet academies of science and various departmental research institutes concern themselves not only with basic and applied natural sciences but with the whole spectrum of knowledge—the humanities, fine arts, and social and political disciplines.

But whatever the agglomeration of the fields of knowledge included in the term *nauka,* there are essentially three distinct pyramids in the Soviet research establishment. As of January 1960, these were as follows.

1) Institutions of higher education—universities and institutes (766 institutions in all), employing 138,000 research and academic personnel, of whom about one-third were actively engaged in research. Their research was coordinated by the Scientific-Engineering Council, established in 1956, within the Ministry of Higher and Secondary Specialized Education.

2) The Academy of Sciences of the U.S.S.R. and the 13 union-republic academies of science (603 institutions), employing 39,317 research workers (*3*). Their research was directed by the Presidium of the Academy of Sciences of the U.S.S.R., which had a special Council for the Coordination of Research Work of the union-republic academies of science.

3) Departmental (ministerial) research and development establishments (1005 institutions), employing 125,413 researchers (of whom 18,830, in 494 research institutes, were under the jurisdiction of 13 functional, specialized academies). No central body for coordinating the research activities of these establishments existed until recently, and "institutional research" mushroomed along functional lines, research institutes being formed by the appropriate commissariat or ministry as the need arose—whether for steam turbines, coal mining, school construction, or space research.

The growth of the Soviet research establishment in the last three decades, and particularly since the mid-1950's, was most intensive in pyramids 2 and 3. Table 4 provides data, as of January 1960, on the number of institutions and of research personnel in the Academy of Sciences of the U.S.S.R. and its regional units (the 13 union-republic academies of science) and in the 13 functional academies. The remaining research personnel (106,653 in 509 research institutes) were employed in departmental research and development institutes under a variety of auspices—of state committees, ministries, and other administrative bodies.

Table 3. Research and academic personnel in the U.S.S.R., by field, 1956 and 1960.

Field	Jan. 1956		Jan. 1960		Index of growth
	Number (thousands)	%	Number (thousands)	%	
Physical sciences and engineering	103.3	46.0	163.5	52.7	159
Biological sciences, medicine, agriculture	51.5	23.0	64.8	20.9	121
Arts, humanities, social sciences	62.6	27.9	74.4	24.0	119
Other	6.5	2.9	7.2	2.4	110
Total	223.9	100.0	310.0	100.0	138

Table 4. Soviet academies of sciences, research institutes and research personnel, January 1960.

	Year founded	Academicians: full and corresponding members (No.)	Research institutes (No.)	Research personnel (No.)
Academy of Sciences of the U.S.S.R.	1725	503	238	23,150
Republic academies*				
Ukrainian S.S.R.	1919	208	60	3,274
Belorussian S.S.R.	1928	76	30	1,250
Uzbek S.S.R.	1943	60	30	1,838
Kazakh S.S.R.	1945	76	37	1,500
Georgian S.S.R.	1941	70	44	2,084
Azerbaidzhan S.S.R.	1945	39	24	1,612
Lithuanian S.S.R.	1941	35	15	499
Latvian S.S.R.	1946	37	20	819
Kirgiz S.S.R.	1954	26	12	544
Tadzhik S.S.R.	1951	29	27	709
Armenian S.S.R.	1943	59	28	1,074
Turkmen S.S.R.	1951	37	21	466
Estonian S.S.R.	1946	32	17	498
Subtotal, republic academies		784	365	16,167
Academy of Construction and Architecture of the U.S.S.R.	1956	196	33	2,642
Academy of Construction and Architecture of the Ukrainian S.S.R.	1956	31	26	1,628
Academy of Arts of the U.S.S.R.	1947	109	4	92
Academy of Medical Sciences of the U.S.S.R.	1944	216	32	2,678
Academy of Pedagogical Sciences of the R.S.F.S.R.	1944	92	13	577
Academy of Communal Services of the R.S.F.S.R.	1931		4	359
Subtotal, functional academies		644	112	7,976
All-Union Academy of Agricultural Sciences	1929	142	165	4,758
Academies of Agricultural Sciences of				
Ukrainian S.S.R.	1957	45	76	1,744
Belorussian S.S.R.	1957	28	23	833
Uzbek S.S.R.	1957	15	41	1,222
Kazakh S.S.R.	1957	20	51	1,142
Georgian S.S.R.	1957	21	11	564
Azerbaidzhan S.S.R.	1958	6	15	591
Subtotal, agricultural academies		277	382	10,854
Grand total		2,208	1,097	58,147

* The Moldav branch of the Academy of Science of the U.S.S.R., which had eight institutes and 272 researchers in 1960, is scheduled to begin functioning as a republic academy of sciences in 1962.

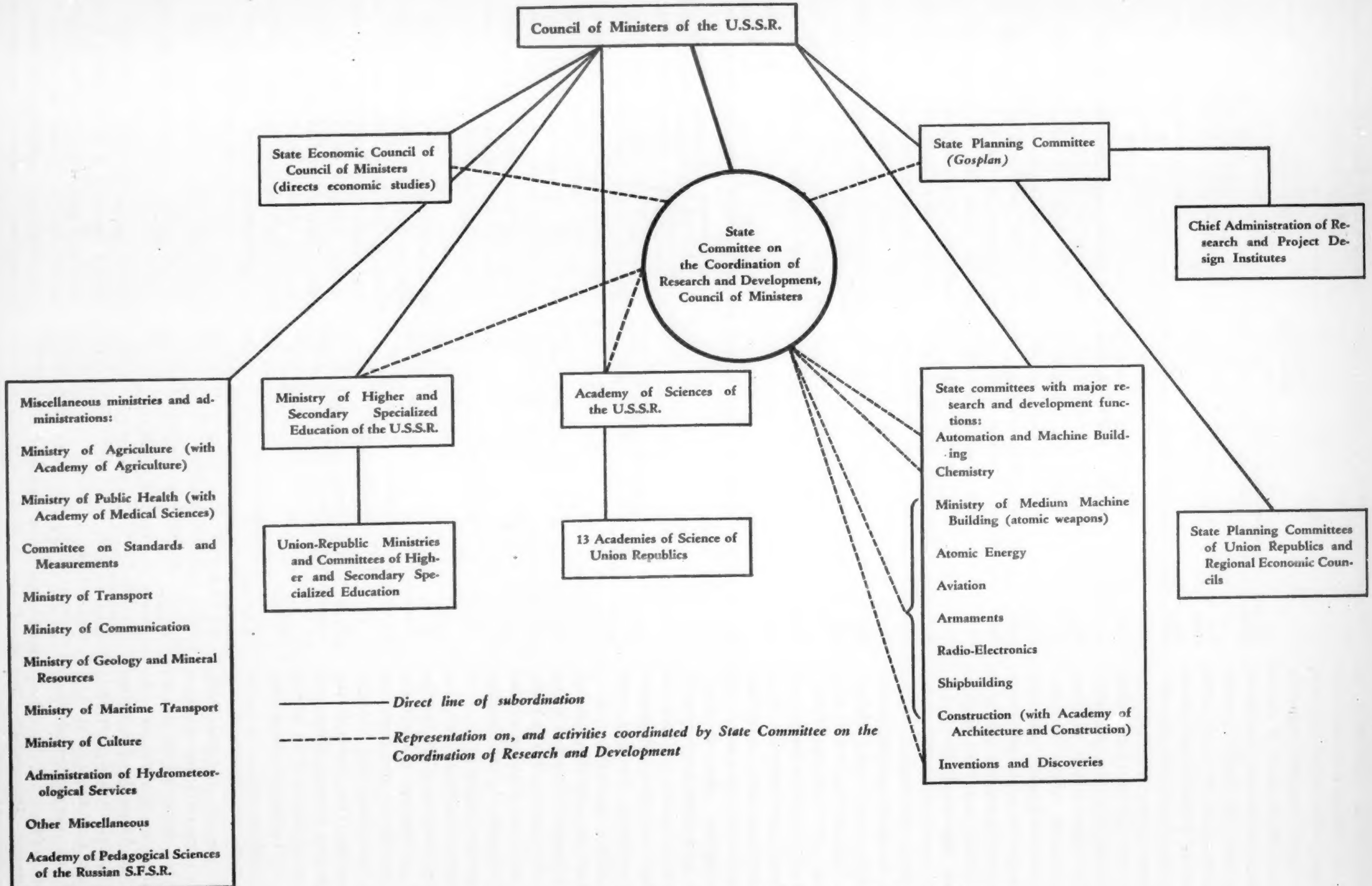

Fig. 1. Organizational structure of Soviet agencies concerned with research and development.

Early Steps in Reorganization

The debate concerning the Soviet science and research setup originated in July 1955. In February 1956, at the 20th Communist Party Congress, Khrushchev declared: "The separation of research activity of the Academy of Sciences, departmental research institutes and higher educational establishments can no longer be tolerated. This separation and lack of coordination prevent the concentration of research activity on the solution of major scientific and engineering problems, lead to duplication of effort and waste of resources, and retard the introduction of research and engineering achievements into production" (*4*).

Although similar thoughts had occasionally been expressed by other Soviet leaders, the demand to streamline the organization of Soviet research and development had never before been presented so forcefully. In 1956 and 1957 a veritable flood of proposals by prominent scientists appeared in the Soviet press, all aimed at streamlining the research organization along the lines of consolidating the fragmented, specialized units and breaking up departmental boundaries.

Meanwhile, beginning in May 1957, the management of Soviet industry was also reorganized, and as a result, a number of departmental research institutes, originally under the auspices of central ministries in charge of particular branches of the Soviet economy, were transferred to regional economic councils or to the newly formed state committees. Among these, the most important was the State Planning Committee, the *Gosplan,* and to it was delegated supervision of the major industrial research and development institutes. By 1958, 323 industrial research institutes, employing 19,000 researchers, were subordinated to the *Gosplan,* which formed a new directorate, the Chief Administration of Research and Project Design Institutes (*Glavnüproekt Gosplana*). This new directorate was to coordinate applied technological research and project-design activity in areas not under the jurisdiction of other state committees. The research and development institutes of other state committees were to carry on both applied and basic research in areas under their jurisdiction, —that is, in radio electronics, aviation engineering, armaments engineering, chemistry, shipbuilding, automation, and machine building. The *Gosplan,* together with the Academy of Sciences of the U.S.S.R., was to participate with these committees in delineating their research functions and coordinating their research objectives. Still, there was no central body to coordinate *all* research and development activity.

In order to speed up the introduction of new technology and scientific discoveries into industry, a separate State Committee on Science and Technology was established (called *Gostekhnika* in 1955, and since May 1957, *Nauchno-Tekhnicheskii Komitet*), which was to conduct research on the uses of new technology, disseminate technological information, and supervise the adaptation of foreign technology.

Academy of Sciences in a Squeeze

During this reorganization turmoil, the Academy of Sciences of the U.S.S.R. came under particularly heavy fire, being pressed not only to intensify its activities on applications for industry but also to direct and coordinate research applications in the other research pyramids. There were three external pressures upon the Academy: political, industrial, and educational.

Political. The Communist leadership insisted upon certain results: an efficient and economical way of conducting research and development activities, a reduction of departmental barriers and unnecessary duplication, and especially a speeding up of the application of research results (particularly in engineering technology) to industry. It wanted the Academy's work geared to these objectives and made "closer to production."

Industrial. The managers of Soviet industry, who were sometimes not eager or were even reluctant to use new technology for fear of disrupting production activity, wanted the Academy's researchers not only to make general scientific investigations and to engage in design and development of products and processes but also to engage in model production and testing and, thereafter, to participate in getting the "bugs" out.

Educational. Although much has been said about the research activities of Soviet universities and other institutes of higher education, for the last three decades the main preoccupation of these institutions has been with academic tasks largely separated from applied research. Universities had indeed carried out some highly theoretical work, but they had only limited access to experimental research facilities. Their applied (contractual) research for industry was small in terms of funds and facilities, though academic personnel frequently participated in the research effort through multiple-job holdings in facilities outside higher education. The educational reforms introduced in 1958 demanded the expansion of research work in higher educational institutions proper, and universities and institutes turned their attention toward the possibility of merging with or absorbing some of the separate research institutes. In order to strengthen instruction in practical applications and to increase research activity, demands were made that a number of the research institutes of the academies should be transferred to higher education auspices.

These three external pressures, however, were counteracted by one fundamental internal force. The scientists engaged in fundamental and theoretical research and the leaders in numerous research institutions of the Academy not concerned directly with applications desired greater emphasis on basic research. They urged the separation of activities and the setting up of new research institutes, not along specialized functional lines but as research task forces or problem areas with an interdisciplinary orientation. In effect, the working theoretical scientists and the leaders of the Academy wanted to rid it of activities which were not genuinely scientific. Largely in compliance with this view and, indeed, in full recognition of the problem, A. N. Nesmeianov, then Academy president, suggested in 1958 that Soviet science "can no longer rely upon foreign basic science . . . what we need now first of all is to develop the fundamental sciences. . . . We need to take decisive measures for the speediest and most widespread development of basic science" (*5*). He then proposed a sharp reorganization of scientific inquiry, with the Academy dealing only in basic research; applied research in technical and engineering fields was to be carried on by industrial institutes. The radical nature of Nesmeianov's proposals—that is, the separation of basic and applied research activities—was a blow at a cardinal assumption of Soviet dogma, that the "unity of theory and practice" is fundamental to dialectical materialism and that the separation of applied and theoretical objectives in research is inadmissible.

In the summer of 1959 Khrushchev recognized that a "difficult situation exists in some institutions of the Academy" (*6*) and suggested that some technical institutes be removed from its jurisdiction since the work of the Academy had become too big and complex for it to continue to have so many technological research functions. The Academy was to continue with experimental research in biology, geology, and some other areas of the natural sciences, but not in such areas of technology as mining, coal, metallurgy, transportation, and other kinds of industrial research.

In keeping with Khrushchev's proposals, Academician N. N. Semenov suggested that the technical sciences division of the Academy be abolished altogether and that its other divisions be consolidated into three major groups: experimental, geological, and social sciences (*7*). Research in engineering and the humanities should be carried on elsewhere. Such an arrangement would break down the narrow disciplinary lines of former Academy divisions and institutes. In the newly organized institutes, the departmental assignment of specialized fields to separate research institutes would thus be abolished. In the ensuing debate Semenov's proposals were supported by many leading scientists but were opposed by the applied-technology hierarchy within the Academy's Engineering Sciences Division, who wanted the Academy to retain tasks in applied technology so as to have a link with industry and production. Despite the opposition, Semenov continued to contend that the "responsibility to the state for developing science should rest with the Academy, and for its technical application with the appropriate research institutes elsewhere" (*8*). The same note was struck again in 1960 by other theoretical sci-

Who's Who in the New State Committee on th

Konstantin N. Rudnev (b. 1911), appointed Chairman of the State Committee on the Coordination of Research and Development of the Council of Ministers of the U.S.S.R. with the rank of Deputy Chairman of the Council of Ministers of the U.S.S.R. on 10 June to replace Khrunichev. Former Chairman of the State Committee on Armaments Engineering of the Council of Ministers of the U.S.S.R. since its establishment in 1958. Mechanical engineer; graduate of Tula Mechanical Institute, 1934. Chief design engineer in armaments research office, 1934–40. Chief engineer, then plant director, in armaments plant, 1940–47. Head of division in the Ministry of Armaments, 1948–52; Deputy Minister of Armaments Industry, 1953–57. Member of the Communist Party since 1941.

Mikhail V. Khrunichev (b. 1901), briefly chairman of the State Committee. In the 1920's was in the Red Army and secret police administration. In 1930–32 studied first in the Voroshilovgrad branch of the Ukrainian Industrial Management Academy, subsequently transferring to the All-Union Industrial Management Institute in Moscow. Industrial management work and later a director of armaments plant, 1932–37. Deputy Head of the Commissariat (Ministry) of Armaments Industry, 1938. Deputy Head of Commissariat of Aircraft Industry, 1932–42. First Deputy Commissar of Armaments Supply and Procurement, 1942–46, with the military rank of lieutenant general. Minister of Aircraft Industry of the U.S.S.R., 1946–53. First Deputy Minister of Medium Machine Building (Soviet atomic energy, weapon development, and production industries), 1953–55. Deputy Prime Minister of the Council of Ministers of the U.S.S.R., 1955–56. Deputy Head of the State Economic Commission, 1956–57. Deputy Chairman of the State Planning Committee, 1957–10 April 1961. Received Stalin prize twice (for aircraft development work) and seven Orders of Lenin. Hero of Socialist Labor (highest civilian award). Member of the Communist Party since 1921. Member of the Central Committee of the Communist Party of the Soviet Union since 1952. Died suddenly on 2 June.

Mstislav V. Keldysh (b. 1911 in Riga), newly elected President of the Academy of Sciences of the U.S.S.R. (19 May 1961). Applied mathematician, expert in aerodynamics and rocket development. Son of a prominent civil engineer (Major General V. M. Keldysh, of the Kuibyshev Military Engineering Academy and the Academy of Construction and Architectural Sciences of the U.S.S.R.). Graduate of Moscow State University, 1931. Doctor of physical-mathematical sciences, 1938 (defended his thesis at Steklov Mathematics Institute of the Academy). Professor of mathematics and member of the academic council (governing board) of Moscow State University, 1932 to the present. Joined the Soviet Union's major aircraft development center, TsAGI (Central Aero-Hydrodynamics Research Institute), in 1931, where during the 1930's he directed research on dynamic properties of wings, vibration problems, landing gear, and other problems of aircraft design and development. In 1943, was chosen to head the research work in the then top secret "Research Institute No. 1" of the Ministry of Aircraft Industry, which engaged in Soviet rocket development. Did research and development work at a "research institute" (classified) of the Ministry of the Aircraft Industry in the 1940's and early 1950's. At the time of his election to the Academy's presidency was "director" and "leader of research" (classified) of "several research institutes conducting work in mathematics and mechanics and charged with the solution of major scientific and engineering development problems in the area of special technology"—that is, the group of research and development centers for missiles and space vehicles managed mainly

entists, and Nesmeianov declared anew his belief that the Academy should engage primarily in basic research (*9*).

The new governmental decree resolves the issue in part at least. It declares: "Institutes of applied specialized profiles, upon the recommendation of the Academy's Presidium, will be transferred to other state committees, ministries and departments" (*10*). If all the Academy's institutes with a technological profile were thus affected, it would mean the transfer of up to 50 research institutes with an estimated 8000 researchers. Furthermore, the regional branch offices of the Academy of Sciences of the U.S.S.R. will be transferred to the jurisdiction of the Council of Ministers of the Russian S.F.S.R. and will be operated by regional economic councils.

In fact, such a decision has already been adopted at the plenary session of the Presidium of the Academy of Sciences of the U.S.S.R., held on 10 April (*11*). Accordingly, exclusive of the Academy's affiliates (branch offices) (*12*), the transfers have so far affected about 30 research institutes, employing bewteen 2000 and 3000 researchers. Affected were not only the industrial research institutes of the Academy's Engineering Sciences Division (*13*) but also institutes under other divisions of the Academy (*14*), the latter also engaged primarily in applied technical research. Despite these proposed cuts, the Academy will still remain the U.S.S.R.'s largest research unit.

The decree stipulated further that "the work of the Academy should be focused primarily on the most important long-run problems of science undergoing rapid development." These functions are precisely the ones which the Academy leadership has been asking for. The Academy will continue to (i) exercise scientific and methodological

Coordination of Research and Development

by the State Committee on Aviation Engineering, Ministry of Medium Machine Building (weapons development), and Ministry of Defense. Was elected corresponding member of the Academy, 1943; full member, 1946; member of the Presidium, 1953; vice president, 1960. Received two Stalin prizes (1942 and 1946, for work in aerodynamics and aircraft development); received the Lenin prize (sometime after 1956, for undesignated work). Is noted for theoretical work in mathematics (calculus of variations, boundary-value problems), applied mathematics (computers), and aerodynamics (has published no research papers in the latter field since 1939). Has received five Orders of Lenin and three Orders of the Red Banner and was named a Hero of Socialist Labor (presumably on 22 December 1957 at the time of the awards for the development of the first Soviet satellite). Communist Party member since 1949.

Viacheslav P. Eliutin (b. 1907), Minister of Higher and Secondary Specialized Education. Engineer; graduate of Moscow Institute of Steel, 1930. Worked as engineer and plant manager in the 1930's. Received degree of doctor of engineering sciences in 1947 and was simultaneously certified in the rank of professor. Director of the Moscow Institute of Steel, 1945–51. Deputy Minister of Higher Education, 1951–54. Received Stalin prize (in metallurgy) in 1952. Communist Party member since 1929. Candidate member of the Central Committee of the Communist Party of the Soviet Union since 1956.

Anatolii I. Kostousov (b. 1906), Chairman of the State Committe on Automation and Machine Building of the Council of Ministers of the U.S.S.R. (set up in 1959), with the rank of minister. Mechanical engineer; graduate of Moscow Machine Tool Institute, 1932. Worked as engineer, manager, and plant director in a number of machine building plants, 1933–46. Deputy Minister (1946–49) and Minister (1949–53) of Machine Tool Industry of U.S.S.R. Minister of Machine Building Industry of U.S.S.R., 1953–54 (which was reorganized as Ministry of Machine Tool and Instrument Industry of the U.S.S.R. 1954–57). Chairman of the Moscow Regional Economic Council, 1957–59. Communist Party member since 1925. Candidate member of the Central Committee of the Communist Party of the Soviet Union since 1952.

Victor S. Fedorov (b. 1912), Chairman of the State Committee on Chemistry of the Council of Ministers of the U.S.S.R. since its establishment in 1958. Chemical engineer; graduate of Groznyi Institute of Petroleum Engineering, 1932. Taught there and received candidate degree in engineering in 1937; was certified associate professor and headed the department of petroleum processing technology, 1937–40. Petroleum plant manager and petroleum trust executive in the newly developed oil region of the Volga, 1940–53. Mainly responsible for the development of fields, cracking installations, and petrochemical plants in that region. Deputy Minister of Petroleum Industry, 1953–57. Chairman of the Bashkir A.S.S.R. Regional Economic Council, 1947–58. Received two Stalin prizes (for petrochemical research). Made a Hero of Socialist Labor in 1952. Has been a member of the Communist Party since 1939.

Alexandr F. Garmashev (b. 1907), Chairman of the Committee on Inventions and Discoveries of the Council of Ministers of the U.S.S.R. since its establishment in 1956. Mechanical engineer; has the degree of candidate in engineering sciences. In the late 1930's and 1940's was manager and director of several shipbuilding, locomotive, and military ordnance plants in the Ukraine. Received Stalin prize (for work in welding technology). Communist Party member since 1938.

leadership and conduct research in the area of the natural sciences (physics, mathematics, biology, and sciences of the "universe and earth"—that is, geology, oceanography, astronomy, and so on); (ii) aid the academies of science of the union republics in their research; (iii) coordinate the activities of all the Academy's institutions; (iv) maintain scientific ties with foreign countries; and (v) engage in the training of research personnel.

The Academy's role in regard to the first of these functions was clarified further to include the coordination of work in those areas conducted not only at the Academy but by other institutes as well, especially by institutes of higher education (*15*). Although the decree does not make it clear, according to Topchiev, the Academy's role in maintaining scientific ties with foreign countries (function iv) will be to coordinate scientific exchanges with foreign countries, and particularly to expand its activities in the exchange and dissemination of scientific information.

Replacement of Academy President

Closely associated with the reorganization moves was the sudden replacement of the Academy's president, A. N. Nesmeianov, by academician Mstislav Vsevolodovich Keldysh, who was elected to that post at an extraordinary general meeting of the Academy on 19 May 1961 (*16*).

The official version of the meeting was that former president Nesmeianov had petitioned to be relieved of his duties because of the "expiration" of his second 5-year term. Technically, however, his term would not expire until October 1961, for he had been elected by the general assembly of the Academy on 13 October 1956. Furthermore, the extraordinary plenary session of the Academy was called together on 19 May by its presidium (governing board) to "ratify" the resignation of Nesmeianov, which had already been "accepted," and to elect a new president, whose candidacy was already endorsed by the Academy's presidium, the "Communist Party group" of the Academy, and by the Academy's eight divisions. Each of these moves indicates clearly that Keldysh, the new president, was co-opted prior to the formal election.

The new president, professor and doctor of mathematical sciences, had a meteoric rise in the largely conservative body of the Academy. Elected as a corresponding member in 1943, he became a full member in 1946 (the span between the two ranks is usually at least 10 years). In 1953 he was elected a member of the Academy's ruling body, the Presidium, and became its vice president in February 1960. He did not at any time belong to the internal managerial hierarchy of the Academy; all of his research work in mathematics, aerodynamics, and aircraft and rocket technology was done outside the Academy's research institutes. He thus belonged to that group of academicians (about half of the total of 161 full and 369 corresponding members) who are in the Academy of Sciences of the U.S.S.R. as honorific members and top-level research coordinators rather than staff scientists in one of its many research institutions. Kelydysh has strong ties with the new head of the Committee on Coordination, having worked in research organizations headed by Khrunichev. In addition, he has a long-standing working relationship with other members of the new committee active in the Soviet military research and development effort.

Keldysh's appointment to the presidency was undoubtedly influenced by the fact that in addition to his scientific competence he has had wide organizational experience with the large-scale research and development effort outside the Academy. It is this research-management experience which is needed in the institutional rorganization and streamlining of the Academy's research functions that are presently under way.

Functions of the New Committee

The State Committee on the Coordination of Research and Development will supervise the work of research and development establishments in fulfilling the most important scientific research and engineering objectives in accordance with the directives of the party and the government. It will coordinate work of the Academy of Sciences of the U.S.S.R., of the academies of science of the union republics, and of ministries and departments in fulfilling the most important research objectives of an interdepartmental or interdisciplinary nature, and it will guide the direction of research and development work up to the point of its adaptation in the national economy.

On the recommendation of the Council of Ministers of the U.S.S.R., the councils of ministers of the union republics, and ministries and departments, the State Committee on the Coordination of Research and Development, together with the State Economic Council (*17*) and the State Planning Committee, will develop plans for research and development work in the country at large and for the introduction of scientific and engineering accomplishments in production. The task of the new committee will be to propose these plans for approval to the Council of Ministers of the U.S.S.R.

The Committee on the Coordination of Research and Development will have the following specific areas of responsibility.

1) National control over the fulfillment, by all ministries, departments, and organizations, of the most important research objectives, and supervision, on an operational basis, of the introduction of scientific and engineering accomplishments into production.

2) Preparation of proposals for research and development work of greatest national significance, and concern with problems posed by new discoveries and inventions.

3) Preparation of proposals concerning the supplying of research and development organizations with special equipment, installations, and instruments.

4) Study and evaluation of scientific and engineering accomplishments (both domestic and foreign) with a view toward their possible introduction into the national economy.

5) Coordination of all interdepartmental activities of ministries, departments, and research and development organizations in the area of science and technology.

6) Preparation of annual and long-run plans for financing material-technical supply of research and development work, including plans for capital investment for the development of science.

7) Certification of major research and development institutes; such institutes may be opened only with the committee's consent. Particular attention of the committee will be devoted to designating "major" institutes (*golovnyi instituty*) which are interdiscipli-

nary or "problem" research centers. They have been set up under different departmental auspices in recent years, and it is anticipated that a number of additional such centers will be established in the near future.

The former State Committee on Science and Technology has been absorbed by the new State Committee on Coordination. The All-Union Institute of Scientific and Technical Information, which was originally subordinate to this State Committee (though operated jointly with the Academy of Sciences of the U.S.S.R.), has now been transferred to the new State Committee on Coordination. As in the past, the Institute of Scientific and Technical Information will be the central translating, abstracting, and disseminating organ for domestic and foreign scientific information.

Except for this scientific information institute, the new State Committee on the Coordination of Research and Development will not operate any research institutes directly; rather, its function will be to guide research activities of an interdisciplinary nature, or of great importance, in research units under the jurisdiction of other state committees or departments. However, as in the past, specialized research and development work not of national significance and not of an interdepartmental or interdisciplinary nature will be coordinated by ministries, departments, and regional economic councils.

Soviet Leaders in Charge of Other State Committees Concerned with Research and Development

Petr V. Dement'ev (b. 1907), Chairman of the State Committee on Aviation Engineering of the Council of Ministers of the U.S.S.R. since its establishment in 1957. Aviation engineer; graduate of Zhukovskii Air Engineering (Military) Academy, 1931. In the 1930's was in air force development and procurement work. Deputy Minister of Aircraft Industry, 1953–57 (until its reorganization into the State Committee on Aviation Engineering). Hero of Socialist Labor (highest civilian award). Communist Party member since 1938. Candidate member of the Central Committee of the Communist Party of the Soviet Union since 1952; has been a full member since 1956.

Leonid Smirnov, new Chairman of the State Committee on Armaments Engineering of the Council of Ministers of the U.S.S.R., appointed 10 June.

Valerii D. Kalmykov (b. 1908), Chairman of the State Committee of Radio-Electronics of the Council of Ministers of the U.S.S.R. since its establishment in 1957. Electrical engineer; graduate of Moscow Power Institute, 1934. Worked as chief design engineer in communciations research and development institute, 1934–49. Headed division of shipbuilding industry, 1949–51. On "special assignment" with the Council of Ministers, 1951–54. Minister of Radio-Electronics Industry, 1954–57. Communist Party member since 1942. Candidate member of the Central Committee of the Communist Party of the Soviet Union since 1956.

Aleksandr I. Shokin, Chairman of the State Committee on Electronic Engineering of the Council of Ministers of the U.S.S.R., which was formed on 8 March 1961. Electronics engineer. In the mid-1950's, Deputy Minister of the Radio-Electronics Industry, and since 1958, Deputy Chairman of the State Committee on Radio-Electronics.

Boris I. Butoma (b. 1907), Chairman of the State Committee on Shipbuilding of the Council of Ministers of the U.S.S.R. since its establishment in 1957, with the rank of minister. Naval engineer; graduate of Leningrad Naval Engineering Institute, 1936. Headed a number of shipbuilding works, 1936–48. Deputy Minister of Shipbuilding Industry, 1944–53. Received Stalin prize (for shipbuilding technology) in 1949. Communist Party member since 1928.

Vasilii S. Emel'ianov (b. 1901), Chairman of the State Committee on Atomic Energy (peaceful uses) of the Council of Ministers of the U.S.S.R. since its establishment in the summer of 1960. Metallurgical engineer; graduate of Moscow Mining Academy, 1928. In the 1930's worked in research and development organizations on ferro alloys, armor plates, and electric furnaces. Deputy Chairman of the Committee on Standards and Measurements, 1940–47. On "special assignment" with the Council of Ministers of the U.S.S.R., 1948–57. Chairman of the Main Administration on Uses of Atomic Energy of the Council of Ministers of the U.S.S.R. (subsequently reorganized into Committee). Candidate member of the Academy of Sciences of the U.S.S.R. since 1953. Received Stalin prize (for ferro alloys). Communist Party member since 1919.

Efim P. Slavskii (b. 1898), Minister of Medium Machine Building Industry [Soviet Atomic Energy, Weapons (including rockets) Development and Manufacturing Industry] of the Council of Ministers of the U.S.S.R. Metallurgical engineer; graduate of Moscow Institute of Polymetals and Gold, 1933. Director of Dnepropetrovsk and Ural Aluminum Combines in the late 1930's and 1940's. In the 1950's was Deputy Minister of the Polymetal Industry and Deputy Minister of Medium Machine Building Industry. Received Stalin prize. Communist Party member since 1918.

Composition of Committee on Coordination

The new decree, which establishes for the first time in Soviet history a central coordinating agency (see Fig. 1) for research and development for the country at large, is to be headed (see pages 1986 and 1987) by a Deputy Chairman of the Council of Ministers (Rudnev, replacing Khrunichev who died on 2 June).

It is to be composed of the President of the Academy of Sciences of the U.S.S.R. (Keldysh); the Minister of Higher and Secondary Specialized Education (Eliutin); the Chairman of the State Committee on Automation and Machine Building (Kostousov); the Chairman of the State Committee on Chemistry (Fedorov); the Chairman of the Committee on Inventions and Discoveries (Garmashev); one of the deputy chairmen of the State Economic Council; and one of the deputy chairmen of the State Planning Committee.

There will also be "other members" of the Committee on the Coordination of Research and Development from other state committees dealing with research and development work (see page 1989). They were not identified by position in the official decree, but definitely the heads of other governmental departments dealing with research and development will be represented. These are chairmen of the following agencies: state committees on aviation engineering (Dement'ev), armaments engineering (Smirnov), radioelectronics (Kalmykov), electronics (Shokin), shipbuilding (Butoma), and atomic energy (Emel'ianov) and the Minister of Medium Machine Building (atomic, and other, weapon development and production) (Slavskii).

The State Committee on the Coordination of Research and Development will form a permanent scientific council, consisting of leading specialists and scientists of the country, with advisory functions, and when the occasion arises, will call for special boards to study specific problems. Particular significance should be assigned to this latter function. Soviet sources indicate that "although about 80 permanent scientific councils are in existence today . . . about one-half of these are inactive" (*15*). The new State Committee on Coordination will thus streamline and activate the work of scientific councils in diverse areas of research, whose activities will now be coordinated by a permanent scientific council (*18*). Through these measures, it is hoped, the "leadership role of scientists now working within the Academy of Sciences of the U.S.S.R. will intensify in the work of the nation's research organization" (*19*).

The new measures to coordinate research and development are obviously designed to give even more emphasis to the physical sciences and engineering and to complex interdisciplinary problems. The important consideration is that the new chairman of the State Committee on Coordination, Khrunichev, is a person with a strong military research and development background. This is also true of the new president of the Academy, who has not only general background in military research and development but also specific experience in rocket and space technology. In addition, most of the heads of the state committees with research and development functions have similar backgrounds. All are former engineers active in defense fields, now turned industrial managers and political leaders. Upon examining their background, it is hard to resist the view that their past interests have profound implications for the future of Soviet efforts in applied research—that these efforts will be technological in nature, with strong military overtones.

Whatever the outcome may be, however, the intended result of the establishment of the State Committee on Coordination will be the synchronization of the Soviet research and development effort in the distinct institutional pyramids—academies, institutions of higher education, and departmental research institutes. What is even more significant, perhaps, is that responsibility for decisions on scientific research and development has now been lodged at the pinnacle of the Soviet power hierarchy; for the first time in Soviet history the Deputy to the Prime Minister (that is, Khrushchev himself) has been charged with the supervision of these tasks.

In regard to other areas of research, it appears that the earlier setup will continue, as follows.

1) Research on economics will be coordinated by the State Economic Research Council of the Council of Ministers, which was set up in 1959, with the chief role assigned to the economic research outlets of the *Gosplan* and with ever-increasing use of mathematical methods of centralized planning and production programming.

2) As in the past, the Academy of Medical Sciences will supervise and conduct medical research, largely sponsored by the Ministry of Public Health.

3) The Ministry of Agriculture, with its All-Union Academy of Agricultural Sciences and five other regional agricultural academies set up since 1957, will coordinate agricultural research and manage experimental agricultural stations. In the areas of medicine and biology, the Academy of Sciences of the U.S.S.R. will not be involved, save for basic research in biology.

4) The State Committee on Construction, with its own Academy of Architecture and Construction (organized in 1956), will coordinate construction and architectural research.

5) Political studies (especially "philosophy") will be guided largely by the Academy of Social Sciences of the Central Committee of the Communist Party.

6) In the field of education, the Academy of Pedagogical Sciences of the Russian S.F.S.R. remains the national clearinghouse and conducts major research.

The new centralization of the decision-making mechanism in Soviet research and development will no doubt be manifested in the near future. Freed from burdensome technological tasks, the Academy of Sciences will be able to concentrate more effort on basic research. Many of its institutes are expected to be reorganized. The Soviet authorities hope that the new measures will (i) improve the system of both long-run and current planning of research and the coordination of research and development activity; (ii) further strengthen theoretical research on the most important scientific problems (within the Academy); (iii) allow for closer ties between departmental research institutes and industry; and (iv) allow more rapid introduction of research-and-development results into production technology and the economy.

The separation of functions must be clearly recognized. On the operational level the Academy will delegate some of its former functions in applied industrial research to other agencies, and within the Academy, institutes will be reorganized in such a way as to cope with complex interdisciplinary and basic research problems, including a very likely increase in the Academy's

role in space exploration. On the consulting and decision-making level the prestige and resources of the Academy will, as in the past, be utilized, though now there will be an intermediate link —the Committee on Coordination— which will in turn exert pressure upon the Academy.

Perhaps these measures are a recognition of a turning point in Soviet technological development: the point of diminishing returns from adaptation of Western technology has been reached, and new and vigorous domestic technological development becomes a necessity. The Soviet political leadership appears to be convinced that the invigoration of technological research activities can be more profitably achieved by separating functions, and by freeing the Academy of Sciences of the U.S.S.R. to concentrate its attention on basic research and the long-run problems of science. Reorganization of the Soviet research setup could provide an effective mechanism for channeling scientific manpower and material resources into strategic areas of the physical sciences and engineering toward the achievement of the most ambitious long-run goal of Soviet power —world leadership in science and technology.

Note added in proof. Right after this article had gone to press, Mr. Khrunichev died of a heart attack on 2 June. His successor, Konstantine N. Rudnev, was named on 10 June.

References and Notes

1. *Pravda* (12 Apr. 1961).
2. Some of the statistical information in this article is taken from N. DeWitt, *Education and Professional Employment in the U.S.S.R.* (National Science Foundation, Washington, D.C., in press).
3. A 14th union-republic academy of sciences is scheduled to begin functioning in the Moldavian S.S.R. in 1962; it is presently a branch of the Academy of Sciences of the U.S.S.R.
4. *Pravda* (14 Feb. 1956).
5. *Uchitel'skaia gazeta* (20 May 1958).
6. *Pravda* (2 July 1959).
7. *Izvestiia* (9 Aug. 1959). Semenov was a Nobel prize winner in chemistry.
8. *Ibid.* (16 Dec. 1959).
9. *Pravda* (31 Dec. 1960).
10. *Ibid.* (12 Apr. 1961).
11. This information was given me by A. V. Topchiev, vice-president of the Academy of Sciences of the U.S.S.R., in Washington, D.C., on 26 and 27 April. Dr. Topchiev attended the plenary session just before his trip to the United States. He indicated that no public announcement of this decision has been made as yet, since the Presidium is still considering the possibility of additional transfers of research institutes.
12. There are seven branches: Bashkir, Dagestan, Karelian, Kazan', Kola, Komi, and Ural. An eighth branch—Moldav—is currently being reorganized into a union-republic academy. The seven branches are being transferred to the jurisdiction of the Council of Ministers of the Russian S.F.S.R.
13. Dr. Topchiev gave as examples the Institutes of Complex Transportation Problems, Metallurgy, and Hydraulic Engineering and Water Economy. In addition, the Institute of Mining will be transferred from the Academy [*Vestnik Akad. Nauk.* **31**, No. 4, 3 (1961)].
14. Dr. Topchiev gave the following as examples: in the Geography-Geology Division, Institutes of Geological Prospecting and of Coal Geology; in the Chemical Division, Institutes of Silicate Chemistry and of Forestry and Wood Chemistry; in the Biological Division, the Institute of Soil Sciences.
15. *Ekonomicheskaia gazeta* (20 Apr. 1961).
16. *Pravda* (20 May 1961); *Ekonomicheskaia gazeta* (20 May 1961).
17. Some of the Academy's institutes which deal with long-range planning, such as the Institute of Complex Transportation Problems, have been transferred to the operating auspices of the State Economic Council.
18. This was especially emphasized by Dr. Topchiev.
19. *Pravda* (21 Apr. 1961).

Radionuclide Fractionation in Bomb Debris

The fractionation systematics for high-yield bursts at sea-water and coral surfaces are delineated.

E. C. Freiling

In radiochemical studies of nuclear detonation debris, the term *fractionation* is used to indicate any alteration of radionuclide composition occurring between the time of detonation and the time of radiochemical analysis which causes the debris sample to be nonrepresentative of the detonation products taken as a whole. The phenomenon has recently been discussed by Adams *et al.* (*1*) and Edvarson *et al.* (*2*) and treated theoretically by Magee (*3*). The alteration observed may have taken place in various stages, and it is helpful to classify these according to the type of processes involved, to list them in approximately chronological order, and to group them under two headings—natural and artifactitious.

Natural fractionation begins with the condensation of radioactive and inert material from the fireball, some radionuclides being preferentially taken up by the condensed phase. The intimate mixture of condensed and solid phase may begin to separate while condensation is still in progress, with further separation of the condensate, according to size, density, and shape, occurring under the influence of wind, gravity, and the turbulence of the cloud. The fractionation taking place through these processes is called primary fractionation in this article.

Further fractionation may then occur through contact of debris with radioactively inert surroundings. For example, soluble radionuclides may be preferentially leached from fallout by sea water, or small particles may preferentially adhere to available surfaces. Fractionation occurring by processes such as these is called secondary fractionation.

Artifactitious fractionation can be induced by sample-collection processes which result in biased samples, by incomplete removal of debris from sampling apparatus, and by faulty analytical procedures.

At this point it appears advisable to introduce two further terms to describe primary fractionation. It is conceivable that in one burst only a small portion of the debris will be sensibly fractionated with respect to two given radionuclides, but that highly unrepresentative ratios of these radionuclides will be produced. In a second burst this pair of radionuclides may be fraction-

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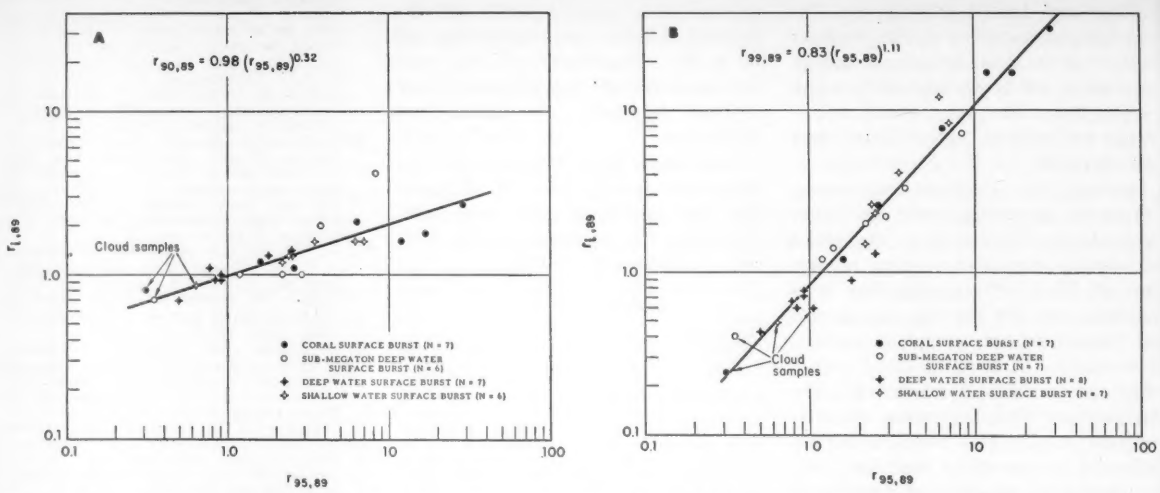


Fig. 1. Logarithmic fractionation correlations for (*A*) strontium-90, (*B*) molybdenum-99, (*C*) tellurium-132, (*D*) cesium-137, (*E*) lanthanum-140, (*F*) cerium-144, (*G*) uranium-237, and (*H*) neptunium-239.

ated throughout the entire debris, but with only small departures from the representative ratio. To distinguish between such types of behavior the term *degree of fractionation* is used to refer to the range of variability of the radionuclide ratio and the term *extent of fractionation* is used to refer to the fraction of the total quantity of these radionuclides which are not present together in the representative ratio. Thus, the first burst referred to above would be said to have fractionated this pair to a high degree but to a small extent, while the second would be said to have fractionated the pair to a low degree but to a large extent.

Importance of Fractionation

An understanding of fractionation phenomena is essential to an understanding of the problems of fallout-contour prediction, device distribution, contamination, ingestion hazard, world-wide fallout, and the nuclear chemistry of the detonation process.

Fallout theories are based upon the gravitational and micrometeorological forces exerted upon the particles resulting from nuclear bomb detonations. The nature of the particles present depends upon the environment, and the ensuing variations in particle size and type are accompanied by variations in radiochemical composition according to the fractionation pattern. Without a knowledge of the latter, correlation and interpretation of field data and prediction of future results is difficult, if not impossible.

In the study of device distribution the term *fraction of the device* is frequently used. This term is undefined for fractionated samples, and the occurrence of completely unfractionated samples is seldom, if ever, demonstrated. Although the term can be redefined in various ways without a knowledge of the degree and extent of fractionation (for example, as "fraction of the device's total gamma-ray activity at time t"), this knowledge is necessary to convert results based upon one definition to results based upon another. Furthermore, through considerations of mass balance, a knowledge of fractionation data can contribute to knowledge of device distribution.

The radiation fields produced by contamination and remaining after decontamination vary with the initial radionuclide composition if fractionation is induced by either of these processes.

The hazard of ingestion of bomb-debris particles is proportional to the presence of isotopes with long biological half-life. To evaluate ingestion hazard from field data, the effect of fractionation must be taken into account.

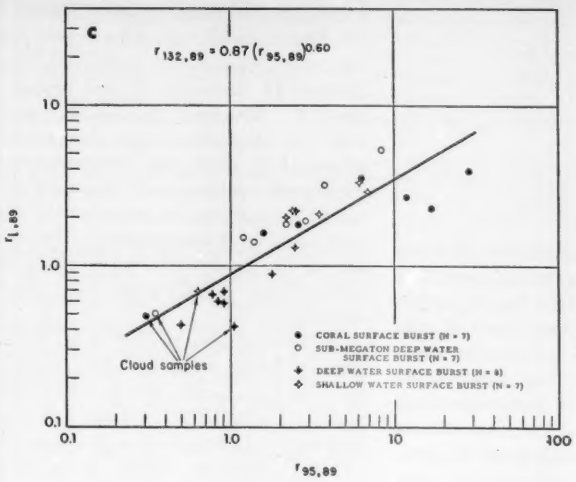
The fraction of strontium-90 contributed to world-wide fallout from a fractionated nuclear detonation cannot be considered equal to the fraction of the gamma-ray activity contributed to world-wide fallout. In the case of high-yield surface bursts, as discussed below, it should be significantly greater.

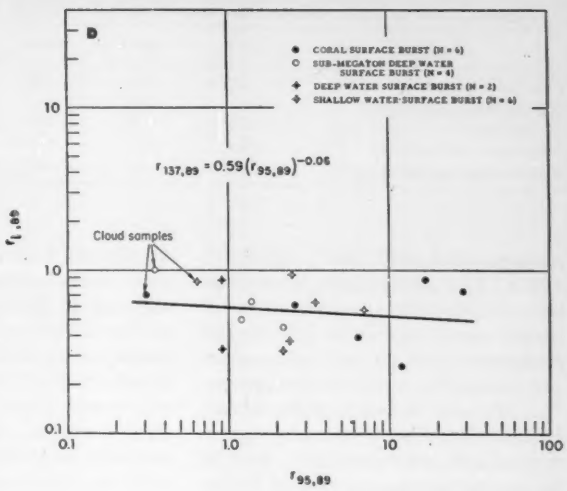
The nuclear chemistry of the detonation process can be studied only in the light of fractionation. An understanding of the fractionation phenomena could lead to a knowledge of the unfractionated composition, which is essential to the study of the primary process. In addition, the dependence of fractionation upon the half-lives and independent yields of volatile precursors relative to condensation time may eventually make possible the study of these parameters through the analysis of fractionated samples.

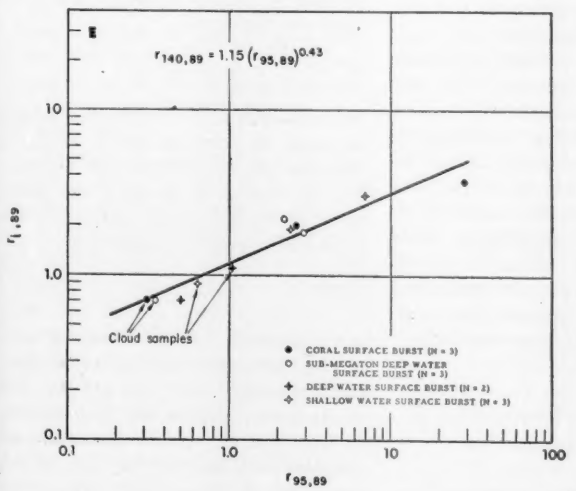
The work discussed here was undertaken to develop empirical relationships for organizing available observations on high-yield surface bursts, illustrate the influence of the nature of the environment, and possibly provide a basis for predicting future fractionation behavior (*4*).

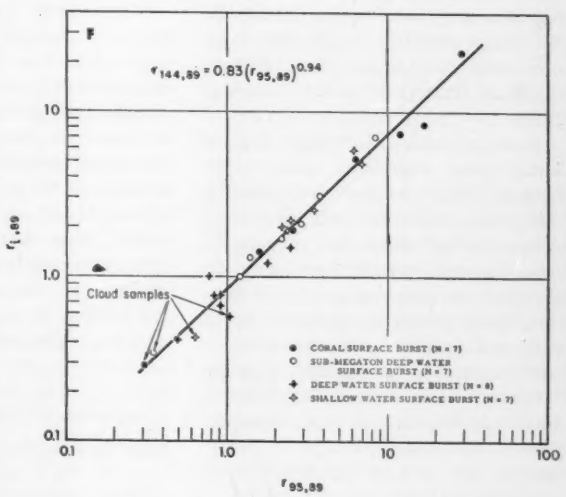
Background

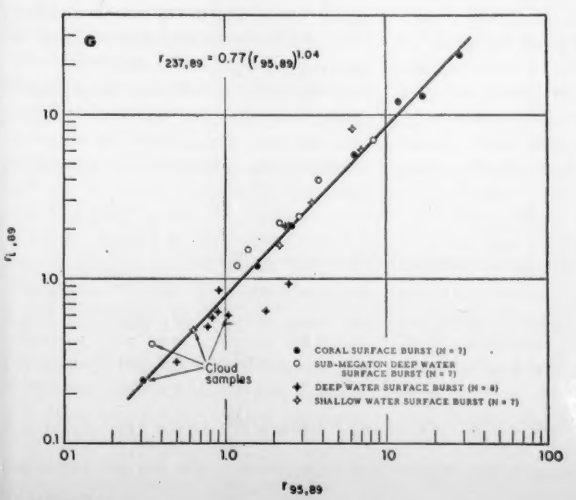
In the atomic cloud the processes of cooling, condensation, coagulation, mixing, and separation occur simultaneously but to different extents in different regions. Furthermore, the initial radioactive products change in elemental form through processes of radioactive decay. The final distribution of each mass chain will therefore be related to its elemental distribution during the various phases of the primary fractionation process. This elemental distribution is simplest in the case of induced activities (Na^{24}, S^{35}, Ca^{45}, Br^{82}, U^{237}, and U^{240}) and of shielded fission


C
$r_{132,89} = 0.87\,(r_{95,89})^{0.60}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 7)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 7)
DEEP WATER SURFACE BURST (N = 8)
SHALLOW WATER SURFACE BURST (N = 7)


D
$r_{137,89} = 0.59\,(r_{95,89})^{-0.06}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 6)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 4)
DEEP WATER SURFACE BURST (N = 2)
SHALLOW WATER SURFACE BURST (N = 6)


E
$r_{140,89} = 1.15\,(r_{95,89})^{0.43}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 3)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 3)
DEEP WATER SURFACE BURST (N = 2)
SHALLOW WATER SURFACE BURST (N = 3)


F
$r_{144,89} = 0.83\,(r_{95,89})^{0.94}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 7)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 7)
DEEP WATER SURFACE BURST (N = 8)
SHALLOW WATER SURFACE BURST (N = 7)


G
$r_{237,89} = 0.77\,(r_{95,89})^{1.04}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 7)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 7)
DEEP WATER SURFACE BURST (N = 8)
SHALLOW WATER SURFACE BURST (N = 7)

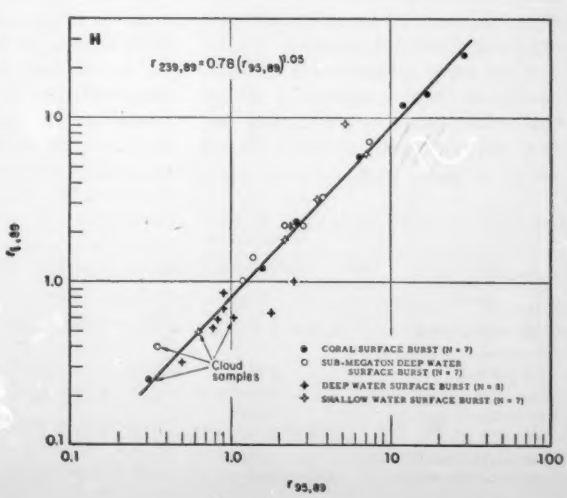

H
$r_{239,89} = 0.78\,(r_{95,89})^{1.05}$
$r_{I,89}$
$r_{95,89}$
Cloud samples
CORAL SURFACE BURST (N = 7)
SUB-MEGATON DEEP WATER SURFACE BURST (N = 7)
DEEP WATER SURFACE BURST (N = 8)
SHALLOW WATER SURFACE BURST (N = 7)

Table 1. Ratio of linear variance from linear fit to linear variance from logarithmic fit.

Burst	Sr^{90}	Mo^{99}	Te^{132}	Cs^{137}	La^{140}
Coral-surface burst	1.13		1.26	0.86	2.85
Sub-megaton deep-water surface burst	0.20	0.37	1.03	2.41	1.36
Deep-water surface burst	1.85	1.52	1.15		
Shallow-water surface burst	1.87		1.18	0.92	4.38

products (Br^{88}, Rb^{88}, Nb^{96}, and Cs^{86}), which do not change form between the time of formation and the time of measurement. Neptunium-239 remains predominantly in the form of uranium-239 during the condensation process. The behavior of fission products such as zirconium-95, molybdenum-99, ruthenium-103, ruthenium-106, and the heavier rare earths is simplified by the absence of volatile precursors, but even here the precursors existing during condensation may have varying affinity for the surfaces available for deposit. Volatile precursors are prominent in mass chains 88 through 97 and 137 through 140.

Factors which favor rapid condensation after detonation cause radionuclides with volatile precursors to fractionate more severely than those with refractory precursors, due to the fact that the volatile precursors are abundant at early times after detonation. Such factors would be low device yield and entrainment by the fireball of cool material with high heat capacity.

Factors which promote occlusion of volatile species tend to offset fractionation. Such factors are a rapid rate of cooling and a high concentration of vaporized material.

Factors, such as the formation of heavy fallout particles, which cause rapid initial settling of condensate from the cloud favor fractionation.

From these considerations it would be expected that fractionation in general would decrease with device yield and increase with proximity to the earth's surface. Thus, airbursts would be expected to fractionate less than surface bursts, surface bursts would be expected to fractionate less than subsurface bursts; and solid environments would be expected to produce more severe fractionation than aqueous environments. However, the phenomenon is so complex, and the data are so scattered, that even such generalizations must be advanced with caution. Air bursts, for example, have been known to fractionate severely.

The number of observations that can be made through radiochemical analysis of fractionated debris is very small compared with the number of different sample types produced and the number of variables requiring investigation. Particulate samples consist not only of particles of many sizes but of particles of many types. Available samples have usually been taken at different times during the period of fallout. In view of this situation, an empirical approach to the problem of fractionation appears to offer the most immediate rewards.

Correlation of Data from High-Yield Surface Bursts

Data suitable for fractionation correlations have been obtained from four high-yield surface bursts: a burst of megaton range at the surface of a coral atoll; a burst of megaton range at the surface of deep water; a burst of submegaton range at the surface of deep water; and a burst of megaton range at the surface of shallow water. Cloud and fallout samples were obtained from these bursts and were analyzed radiochemically for strontium-89, strontium-90, zirconium-95, molybdenum-99, tellurium-132, cesium-137, lanthanum-140, cerium-144, uranium-237, and neptunium-239. Standard procedures were used for all radionuclides except lanthanum-140, which was determined by gamma-ray spectrometry. The data obtained are assumed to represent the results of natural fractionation. The unknown but presumably minor effect of artifactitious fractionation has been neglected.

Preliminary treatment of data. Consider a fission event in which a total of F fissions occur and in which the yield of radionuclide i (either a fission product or a product of induced activity) is Y_i atoms per fission. If the total number of atoms A_i of any such radionuclide be determined by radiochemical analysis, a value of F can be calculated from the results as

$$F_i = A_i/Y_i$$

and all values of F_i so obtained should be equal. If, however, only a sample of the products is available for analysis, and the number of atoms a_i are determined by radiochemical analysis, values f_i may be similarly calculated as

$$f_i = a_i/Y_i$$

but agreement will be obtained only among those radionuclides which have not fractionated from one another, and variance of f_i values will be indicative of fractionation. Initial conversion of the data into this form by use of the appropriate Y_i values was necessary to eliminate nuclear-physical effects, such as the dependence of the yield of a given mass chain on neutron energy and fissile material, which have no bearing on the present problem.

With zirconium-95 and strontium-89 chosen as reference radionuclides, values of $r_{95,\,89}$, defined as the ratio f_{95}/f_{89}, were then calculated for each sample

Table 2. Least-squares slopes and 95-percent confidence limits of logarithmic fractionation correlations.

Burst	Sr^{90}	Mo^{99}	Te^{132}	Cs^{137}	La^{140}	Ce^{144}	U^{237}	Np^{239}
Coral-surface burst	0.24 ± 0.12	1.10 ± 0.11	0.40 ± 0.21	−0.03 ± 0.39	0.37 ± 0.86	0.92 ± 0.12	1.02 ± 0.22	1.02 ± 0.06
Sub-megaton deep-water surface burst	0.52 ± 0.40	0.89 ± 0.08	0.72 ± 0.13	−0.42 ± 0.51	0.52 ± 1.82	0.94 ± 0.09	0.91 ± 0.09	0.90 ± 0.12
Deep-water surface burst	0.41 ± 0.21	0.60 ± 0.23	0.59 ± 0.50		0.62	0.70 ± 0.44	0.48 ± 1.26	0.56 ± 1.20
Shallow-water surface burst	0.38 ± 0.18	1.32 ± 0.34	0.60 ± 0.23	−0.04 ± 0.70	0.55 ± 0.62	1.06 ± 0.19	1.15 ± 0.22	1.16 ± 0.30
Cumulative slope for high-yield surface bursts	0.32 ± 0.08	1.11 ± 0.09	0.60 ± 0.14	−0.06 ± 0.31	0.43 ± 0.09	0.94 ± 0.06	1.04 ± 0.10	1.05 ± 0.09

Table 3. Least-squares intercepts and 95-percent confidence limits of logarithmic fractionation correlations.

Burst	Sr^{90}	Mo^{99}	Te^{132}	Cs^{137}	La^{140}	Ce^{144}
Coral-surface burst	-0.01 ± 0.11	0.06 ± 0.10	0.03 ± 0.19	-0.24 ± 0.39	0.07 ± 0.58	-0.07 ± 0.11
Sub-megaton deep-water surface burst	0.04 ± 0.23	0.00 ± 0.04	0.04 ± 0.06	-0.20 ± 0.08	0.09 ± 0.61	-0.06 ± 0.05
Deep-water surface burst	0.00 ± 0.46	-0.16 ± 0.05	-0.24 ± 0.10		0.03	-0.10 ± 0.09
Shallow-water surface burst	-0.06 ± 0.09	-0.12 ± 0.19	-0.03 ± 0.13	-0.25 ± 0.35	0.05 ± 0.34	-0.12 ± 0.10
Cumulative intercept for high-yield surface bursts	-0.08 ± 0.05	-0.08 ± 0.05	-0.06 ± 0.08	-0.23 ± 0.20	0.06 ± 0.04	-0.08 ± 0.04

as a measure of the degree of fractionation present. These nuclides were chosen because their tendency to fractionate from one another makes $r_{90,\,\infty}$ a sensitive function of the degree of fractionation, because their yields and half-lives are such that they can be determined in samples of relatively low activity, and because they are sufficiently long-lived to be measurable at late times after detonation. The $r_{90,\,\infty}$ values obtained varied by a factor of 5 for the deep-water surface burst of megaton range, of 20 for the deep-water surface burst of submegaton range, of 12 for the shallow-water surface burst, and of 100 for the coral-surface burst.

The ratios $r_{i,\,\infty}$, defined as f_i/f_∞, were then calculated for each of the remaining radionuclides in each sample studied. These were plotted logarithmically against $r_{90,\,\infty}$. It was found that the data thus plotted could be fitted with straight lines and that all lines passed near the intersection of the unit axes. Slopes of approximately 1 were observed for cerium-144, uranium-237, and neptunium-239, and, in the cases of the land-surface and shallow-water surface bursts, for molybdenum-99. The cumulative plots of the data are shown in Fig. 1.

Comparison of linear and logarithmic correlation. Stevenson (*5*) has made linear correlations of fractionation data from less highly fractionated samples than we have observed. When a wide range of fractionation is observed, however, linear graphs are incapable of portraying both extremes of fractionation on an equal basis, with the result that the detail near the origin is suppressed. Since the data appear to fall near a straight line in either case, the first question to be examined is whether linear or logarithmic correlations fit the observed data more closely. This was investigated by making least-squares fits of the data in both linear and logarithmic form and comparing the variances. Strictly speaking, the usual least-squares equations do not apply to the case at hand. Inherent in their derivation is the assumption that the abscissa values are known with much greater precision than the ordinate values, while here the two are known with approximately equal precision. However, because it was expected that results would be used as though abscissa values were accurately known, the usual equations were used. Both linear and logarithmic variances were expressed in the linear form

$$s^2 = \frac{\Sigma(r_{i,\,\infty} - \tilde{r}_{i,\,\infty})^2}{N - 2}$$

for comparability. Here N is the number of observations, and the tilde signifies the values of the ordinate as computed from the empirical equation. The ratios of logarithmic to linear variance thus expressed are shown in Table 1 for those cases where the slopes differed appreciably from unity. From the data it would appear that logarithmic correlation is definitely preferred for tellurium-132 and barium-140, while for strontium-90, molybdenum-99, and cesium-137 the type of correlation preferred may depend upon the yield. On the whole, the data favor logarithmic correlations, but the preference is far from decisive. Since the results of a single analysis can have a large effect on the ratio presented, further evidence is needed before any firm conclusions can be drawn.

Comparison of slopes for logarithmic correlations. The values of the slopes obtained from least-squares fits to the logarithmic data are shown in Table 2, together with the 95-percent confidence limits calculated from the *t*-table. In addition there are shown the slopes and confidence limits for the cumulative data for each radionuclide. These were obtained by fitting the lines to all the data for a given radionuclide, regardless of burst. The cumulative least-squares lines are shown in Fig. 1. (*A–H*). It may be seen that, except for molybdenum-99 in the two deep-water surface bursts, the cumulative slopes are within the confidence limits for the individual slopes. In these cases the slope is at least an insensitive function of the environments studied and may be used to predict fractionation behavior in future high-yield surface bursts. In the water-surface bursts, molybdenum-99 appears to behave more like tellurium-132 than like zirconium-95.

Comparison of intercepts for logarithmic correlations. The least-squares values of the intercepts and the associated 95-percent confidence limits are shown in Table 3. If the intercepts represent the unfractionated composition, all values should be zero within the confidence limits of the results. Consistent departures from zero, as shown in the case of cerium-144, may merely indicate systematic errors in the calibration and conversion factors used. The cumulative values of the intercepts fall within the limits of the individual values for all radionuclides except molybdenum-99 and tellurium-132. For each of these radionuclides the discrepancy appears to be due to the deep-water surface burst of megaton range, since all other values are zero within the limits of the data. The cumulative intercepts for the remaining radionuclides are not sensitive to the nature of the surfaces studied and may be used to predict fractionation behavior.

Goodness of fit. In addition to the variance, a more readily interpretable measure of the goodness of fit is given by the ratio of predicted-to-observed value for the point that shows the poorest fit. This ratio is given in Table 4 for each radionuclide studied. Where the ratio is less than unity, the recip-

Table 4. Predictability factors for points with the poorest fit.

Radionuclide	Predictability factor
Mo^{99}	1.9
Sr^{90}	2.2
Te^{132}	2.1
Cs^{137}	2.0
La^{140}	1.4
Ce^{144}	1.5
U^{237}	2.2
Np^{239}	2.1

rocal is given instead, in order to facilitate comparison. It may be seen that, even in the cases of poorest fit, the cumulative lines predict the data to within a factor of about 2.

Correlation of slopes with precursor volatility. It has long been recognized that fractionation is primarily caused by the presence of volatile precursors in the decay chains of the fractionating radionuclides. The decay chains of the fission-product radionuclides correlated were taken from the Bolles-Ballou compilation (*6*) and modified according to more recent results; they are presented in Fig. 2. Included are chains for uranium-237 and neptunium-239. Below each element in a given chain is presented the fractional chain yield, as calculated (i) by the theory of Present (*7*) and (ii) by the theory of Glendenin, Coryell, and Edwards (*8*).

To illustrate the dependence of the slopes found upon the volatility of the precursors, and at the same time to obtain an empirical correlation between slopes and volatility, the following procedure was followed. First, the fraction of the decay chain existing in a refractory form at a given time was calculated from the Bolles-Ballou compilation, according to Present's theory, and designated F_R. It was assumed that halogens, rare gases, alkali metals, and tellurium were volatile. The cumulative slopes were then plotted against $F_R^{1/2}$ for values of F_R calculated at 35 seconds. The results are shown in Fig. 3. It may be seen from the figure that the cumulative slopes equal $F_R^{1/2}$ within their confidence limits. It should not be inferred from this relationship that the condensation time is actually 35 seconds or that there is any theoretical significance to the function $F_R^{1/2}$. Condensation probably occurs over an extended period of time. The fractional chain yields are not well known, nor are some of the half-lives involved. Furthermore, the fractional chain yields vary with fissile material and neutron spectrum. To repeat, for emphasis: the correlation is intended only to illustrate the relationship between precursor volatility and slope and to provide a rough rule of thumb for estimating slopes of unobserved radionuclides. This rule may be written

$$\log r_{1,\,80} = F_R^{1/2} \log r_{95,\,80}$$

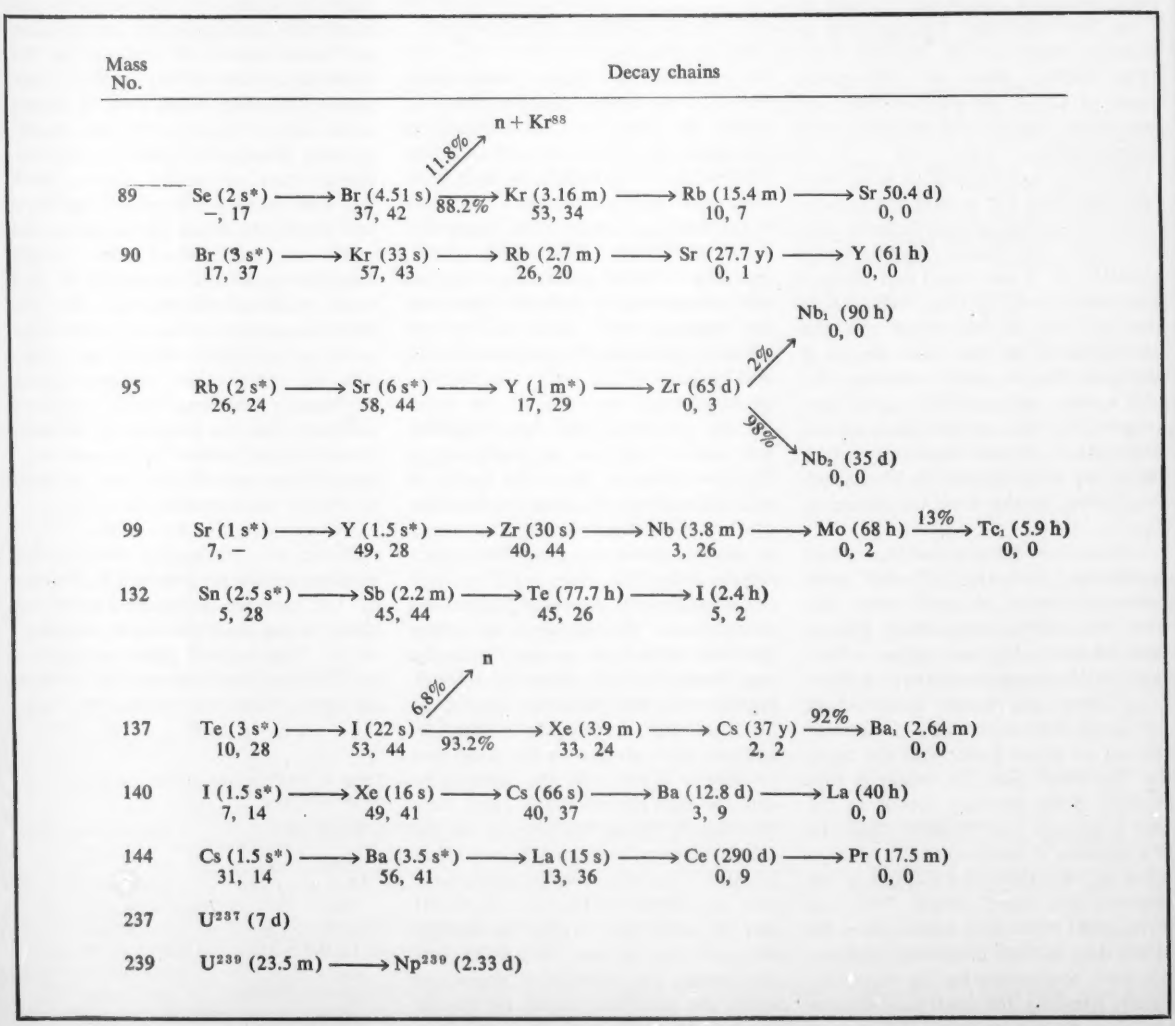


Fig. 2. Decay chains of radionuclides studied. Half-lives in parentheses (asterisks indicate estimated values).

Possible Applications

Correlation with fallout pattern. In all cases except that of the deep-water surface burst, the cloud sample was found to be rich in strontium-89. Beyond this it has not been possible to make any meaningful correlation between sample location and degree of fractionation for the samples studied. This is at least partially due to the fact that the number of samples studied is inadequate as compared to the complexity of the fallout patterns. The correlations developed, however, give rise to the expectation that in any future detonation, sufficient documentation could be achieved to obtain the desired correlation by analyzing a large number of samples for one refractorily behaving nuclide (Zr^{95}, Ce^{144}, U^{237}, or Np^{239}) and for one volatilely behaving nuclide (Cs^{137} or Sr^{90}), inferring the remaining composition from more complete analyses performed on selected samples of varying degrees of fractionation.

Fraction of the device. From the results presented, it may be seen that, in shots of the type studied here, there is a fairly large group of refractorily behaving radionuclides which do not grossly fractionate from zirconium-95 in even highly fractionated samples. It is expected that niobium-95, zirconium-97, niobium-97, rubidium-103, and all mass chains above 144 would behave similarly. If one of these radionuclides —say zirconium-95—were chosen for documentation, it would appear most reasonable and convenient to relate device distribution to the time-independent quantity "fraction of the device's zirconium-95." This quantity should then be very nearly equal to the fraction of the device's refractorily behaving radionuclides. Because of the large number of high-yield radionuclides involved, the corrections necessary to convert from this quantity to other quantities of interest, such as the "fraction of the device's gamma-ray activity at time t," would be minimized in both number and magnitude. The same principle would apply to the correction for variation of survey-instrument response with radiochemical composition.

Device distribution. From the correlation data the number of fissions at any location calculated from the mass i radionuclide is related to similar quantities for zirconium-95 and strontium-89 through the slope b by the equation

$$f_i = f_{95}^{b_i} f_{89}^{1-b_i} = r_{95,\,89}^{b_i-1} f_{95}$$

From mass balance considerations, integration over the contaminated environment gives the total number of fissions

$$\int df_i = F = \int df_{95}$$

Therefore, as a check of consistency between device distribution data and fractionation data, the equations

$$\int r_{95,\,89}^{b_i-1}\, df_{95} = \int df_{95}$$

should be satisfied for every radionuclide studied.

Contamination-decontamination. The first and second beta-decay products of rare-gas radionuclides are alkali metals and alkaline earth metals, respectively. These daughters tend to be concentrated in the surface regions of fallout particles and also to exhibit high solubilities. As a result, these volatilely behaving fission products are more easily leached from the fallout by aqueous media than the refractorily behaving radionuclides. One would therefore expect that the results of contamination or decontamination processes involving an aqueous phase, when measured in terms of gross activity, might differ considerably for volatile-rich and volatile-poor debris which were otherwise similar. In order to insure meaningful results from such studies, then, the radiochemical composition of the debris would have to be known, and contributing variations in composition would have to be accounted for. For high-yield surface bursts, the composition could be estimated from a knowledge of $r_{89,\,\infty}$, on the basis of the results presented here.

Nuclear chemistry. Suppose that a device has been detonated for which the values Y_i are unknown, and that no unfractionated samples are available. Suppose, however, that the fractionation correlation curves can be assumed to intersect at a point, from previous experience with devices of similar yield detonated under similar conditions. Correlation curves, either linear or logarithmic, can then be constructed. If it

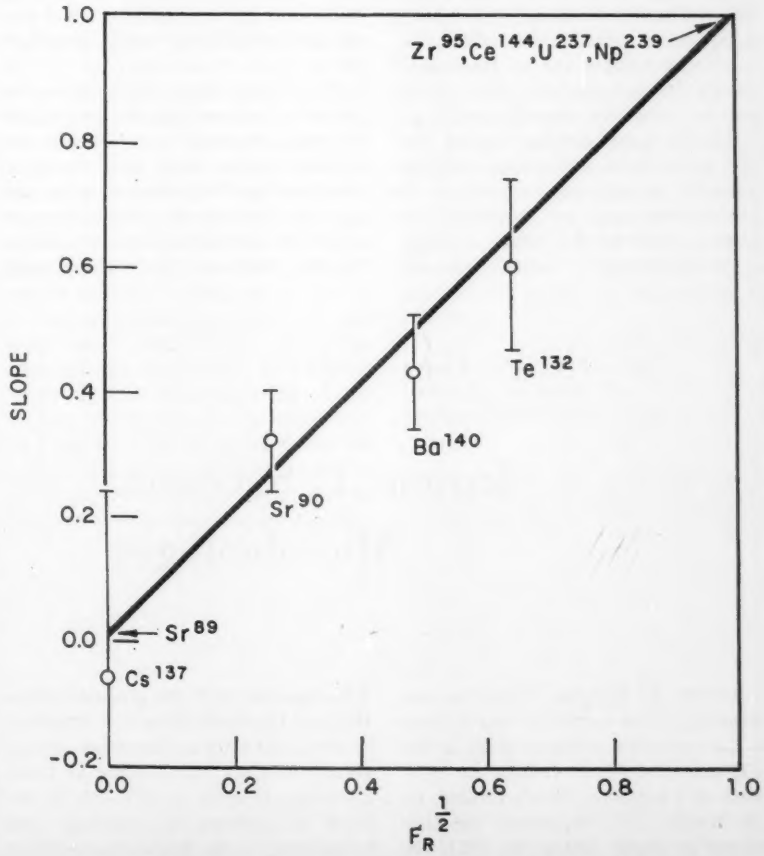


Fig. 3. Dependence of correlation slope on volatility of the precursor.

is now assumed that $Y_{95} = Y_{140}$, the values for unfractionated composition can be determined from the intersections of the curves with the vertical line through the point at which $f_{95} = f_{140}$. An estimate of the validity of the assumption that $Y_{95} = Y_{140}$ can be obtained from values in Table 5, as calculated from the Katcoff compilation (*9*).

Table 5. Variation of mass-140/mass-95 yield for various conditions of neutron fission.

Fissioning nucleus	Neutron energy	Y_{140}/Y_{95}
U^{235}	Thermal	1.03
U^{233}	Thermal	1.02
Pu^{239}	Thermal	0.96
U^{238}	Fast	1.00
Th^{232}	Fast	0.94

Prediction of future behavior. The correlations presented here may be useful in estimating fractionation behavior in future high-yield sea-water surface and coral-surface bursts. It is to be expected that fractionation behavior from lower-yield devices, and from high-yield devices detonated over other surfaces (for example, silicate), may differ significantly from that presented here. In the absence of specific information, however, the behavior presented here may prove to be a useful basis of approximation for planning purposes.

Summary and Discussion

The empirical approach taken here to the problem of fractionation has led to a number of valuable correlations.

1) The composition of fractionated samples from high-yield surface bursts can be correlated logarithmically.

2) The slopes obtained for the various mass chains (except for molybdenum-99) are relatively insensitive to the environment and are empirically related to precursor volatility.

3) Zirconium-95, cerium-144, uranium-237, and neptunium-239 do not fractionate grossly from one another, nor does molybdenum-99 fractionate from these radionuclides when coral is in the environment; cesium-137 does not fractionate grossly from strontium-89. The fact that the slopes of the correlation curve for two radionuclides are identical within their respective margins of error cannot be interpreted as meaning that no fractionation was observed. Small degrees of fractionation between similarly behaving radionuclides are best tested by plotting the ratio of their f values against the fractionation index.

4) Even the data with the poorest fit fall wide of the correlation lines only by a factor of about 2.

5) In all cases except that of the deep-water surface burst, the cloud sample was found to be rich in strontium-89.

It is evident at this point that several pieces of information are lacking for the data presented here. First in importance is the effect of artifactitious fractionation. The extent to which this has contributed to the scatter of points about the correlation lines is undeterminable. Because of the relatively small number of points, any error in the data from the most highly fractionated sample for a given burst would severely affect the type of correlation preferred and the resulting slope.

The behavior of the deep-water surface burst is anomalous in a number of respects, and supporting information on such detonations is needed.

The conditions studied represent a small proportion of the many possible conditions. The findings will have to be viewed in the light of similar studies on many other types of bursts before any firm conclusions and reliable generalizations can be reached.

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4. I wish to acknowledge the excellent work of L. R. Bunney, who supervised the preparation and distribution of samples, coordinated the radiochemical analyses, and accumulated the fission-product results; of L. Wish, who performed the majority of U^{237} and Np^{239} analyses; of Miss E. M. Scadden, who made the Mo^{99} determinations; of J. Pascual, who made the Te^{132} determinations; of J. L. Mackin, P. O. Strom, and D. MacDonald, who performed the Sr^{89}, Sr^{90}, Cs^{137}, and Ce^{144} analyses; and of W. E. Thompson and P. D. LaRiviere, who obtained the La^{140} results. The comments of C. E. Adams have been most helpful in preparing this article.
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Jerome T. Syverton, Microbiologist

Jerome T. Syverton began an outstanding, active career in microbiology as an instructor in bacteriology at the University of North Dakota in 1928. Born in Courtenay, North Dakota, on 29 March 1907, he entered the University of North Dakota in 1923, obtaining an A.B. degree in 1927 and a B.S. degree in 1928. He graduated from Harvard University School of Medicine in 1931, and after an internship and assistant residency in medicine at Duke University Hospital in 1931–32, he became an assistant in pathology and bacteriology at the Rockefeller Institute for Medical Research. There he obtained basic knowledge in virology under the guidance of P. K. Olitsky, and in 1932 he became a member of the faculty of the University of Rochester School of Medicine and Dentistry. He remained at Rochester until 1947, except for a sabbatical leave in 1942 at Vanderbilt University School of Medicine, as visiting associate professor of pathology and bacteriology.

Syverton's development of outstanding skill as a teacher and student adviser and his fundamental and pioneering work, involving, for example, tumor viruses and multiple viral infections of single animal cells, occurred during the period 1934–47, while he was in the department of bacteriology at the University of Rochester. For his outstanding research in virology he received the Lilly award in bacteriology

and immunology in 1938. From 1944 to 1946 he was on active duty in the United States Navy, first as a visiting investigator at the Rockefeller Institute, then as a member of Naval Medical Research Unit 2 in the Pacific Theater. In 1947 he became professor and head of the department of microbiology at Louisiana State University School of Medicine, and from 1948 until his death on 28 January 1961, he was professor and head of the department of bacteriology at the University of Minnesota.

During his academic career his enthusiastic and vigorous approach to professional life, with simultaneous devotion to his family and friends, set an extraordinary example for students and associates. His graduate and postdoctoral students during his 12 years at the University of Minnesota alone numbered over 65. To quote Richard E. Shope of the Rockefeller Institute, "One of the very nicest things that I know about Dr. Syverton was the generosity with which he shared his scientific ideas, and their exploitation, with others, usually graduate students or younger assistants in his department. He published almost none of his most significant observations alone and, where he shared in the publication with others, his name was almost never in the senior author position" (*1*).

Syverton's productivity as an investigator was remarkable, and during 1957–58 he was the recipient of the Commonwealth Fund award for creative work. Eighty-seven articles describing his own work and 119 describing work done in conjunction with his students and associates were published between 1933 and 1960. In the words of Shope, "Dr. Syverton was a prolific worker in the field of virology and his interests ranged widely. He worked first at the Rockefeller Institute on the viruses of vesicular stomatitis and equine encephalomyelitis, sharing in pioneer work in these agents. Later at Rochester, he

Jerome T. Syverton. [Zintsmaster's]

initiated work with the rabbit papilloma, and his continuing studies of the papilloma-to-carcinoma sequence in this virus-induced tumor contributed materially to our understanding of the progression through which a benign tumor cell acquires malignant properties. It was at Rochester too that, with Berry, he did his fundamental work dealing with multiple viral infections of single host cells, showing that the cells of virus-induced tumors could be superinfected with other non-neoplastic viruses. From time to time throughout his career, Dr. Syverton contributed significantly to our understanding of the possible mechanisms by which viruses prevail and are perpetuated in nature. In this connection, he studied the host range of Western equine encephalomyelitis virus in various wild animal species and showed the hereditary transmission of this virus in the wood tick. In a similar vein, he demonstrated the potentiality of the trichina worm to serve as a transmitting agent for the virus of lymphocytic choriomeningitis. Later he extensively exploited the use of stable strains of mammalian cells, in the cultivation and study of viruses. This was a pioneering effort of great importance to virology. Lately, with Brand, he developed a hemagglutination test for the species determination of cultivated mammalian cells. What was probably Dr. Syverton's most significant contribution was made very recently when he discovered with McLaren and Holland that the ribonucleic acid of poliovirus could infect nonprimate cells that were ordinarily refractory to infection with complete poliovirus. The importance of this discovery is very great and its significance to virus work in general and tumor virus work in particular will undoubtedly be far-reaching."

Syverton's stature in science and academic medicine was evidenced by his membership in 22 professional societies and on 11 scientific advisory committees, and his enthusiastic support of science at an international and national level was widely recognized and appreciated. The world's scientific community has lost a creative and productive investigator; the educational community, an enthusiastic teacher; the community of his colleagues and associates, a true friend; and his family, an affectionate and lovable father. As Shope expressed it in speaking of him to Minnesota medical students, "Dr. Syverton was a fine scientist, a gentleman, and a grand person to have as a personal friend. I think that you were fortunate indeed to have had him as one of your professors for as long as you did."

WILLIAM F. SCHERER
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Note

1. R. E. Shope, in "The case of a lurking virus and its exposé," a lecture presented to medical students at the University of Minnesota on 14 Feb. 1961.

Science in the News

Project Chariot: Two Groups of Scientists Issue "Objective" But Conflicting Reports

Two groups of scientists have turned out reports on the possible risks involved in Project Chariot, a proposal to use nuclear explosives to create an artificial harbor on the arctic coast of Alaska. The sharp contrast between the reports suggests that one or both must fall considerably short of the objectivity intended by the authors of each.

The Atomic Energy Commission published a "first summary" by its Committee on Environmental Studies for Project Chariot. This found no significant radiation hazard in the project, and suggested that none was likely to turn up during its further investigations. The committee, as required by law, was chaired by an AEC scientist. It included three other government scientists—one each from the Office of Naval Research, the Public Health Service, and the Geological Survey—plus two American radiation biologists and a Canadian zoologist. Their report was unanimous.

The contrasting report was issued by the Greater St. Louis Committee on Nuclear Information, which describes itself as "the pioneer citizens group in nuclear education." According to the committee, "CNI does not stand for or against particular policies. It presents the known facts for people to use in deciding where *they* stand on the moral and political questions of the nuclear age." For this reason the CNI report took no position on the wisdom of going ahead with the project, although the report noted a number of conclusions based on its appraisal of the facts.

Among the points made in the CNI report are the following: that the site of the proposed test is "peculiarly liable to any risk of biological damage that might result from the radioactive fallout produced by the test"; that "a conservative judgment of the amount of fallout expected from Project Chariot would require that the AEC estimates be multiplied by 10"; that "the fallout from the proposed explosion will add to the present strontium-90 levels by an amount that cannot now be estimated with any degree of precision"; and that "in the present state of knowledge about the effects of radiation, no firm prediction can be made regarding the ultimate harm that may result from the present levels of strontium-90, or from any increase that may be brought about by Project Chariot fallout." The reader is reminded that "according to the current philosophy of radiation protection, it is assumed that every increase in radiation exposure carries with it an increased risk of disease. A brief summary is provided of the objectives of the experiment, and the reader is invited to come to his own conclusion about the relative risks and gains of the project.

The report is titled, "Project Chariot: A complete report on the probable gains and risks of the AEC's Plowshare project in Alaska." The contrasting report of the AEC advisory committee is called "Bioenvironmental features of the Ogotoruk Creek area, Cape Thompson, Alaska: A first summary by the Committee on Environmental Studies for Project Chariot."

The AEC report was based on the results of 30-odd studies commissioned by the AEC to provide a basis for the AEC committee's evaluation. Other studies are under way and will be incorporated into the committee's final report, due next April. The 30-odd completed studies were made public, and also provided most of the data for the CNI report.

For the general public, the difficulty with the AEC report is that, except for stating a conclusion that radiation effects would be "negligible, undetectable, or possibly nonexistent in areas distant from the excavation," it says very little about the radiation problem. There is nothing to indicate the basis for this conclusion; nothing to indicate what is meant by the term *distant;* and nothing about the nature of the food chain in the area, which would lead to a higher absorption of strontium-90 by the population than one might expect.

AEC officials stress that this is only a preliminary report; that the Commission had scrupulously avoided telling the committee what they should say; and that the report is, in any case, a technical summary submitted to the AEC and not written with the general public in mind.

But the AEC report was made available to the general public, and therefore must be judged to some extent on the impression it leaves with the general public. And here the AEC, at the least, would appear to have shown a poor sense of its public relations problem in failing to make emphatic, in the accompanying press releases, that the report does not represent the completed findings of the research program, which is still in progress, and that, in any case, the publication of the preliminary report is not meant to imply that the AEC has made a final decision on the radiation hazards, or would make one without supplying the public with full knowledge of the basis of such a decision.

St. Louis Report

On the other hand, the CNI report is concerned with little else but the radiation hazard, although whether CNI dealt with the problem in a way best calculated to serve its stated purpose of providing the general public with "complete" information on which to evaluate the project is quite another question.

The CNI report contains two major articles. One, an analysis of the AEC's fallout estimates, concludes that the fallout (actually the AEC's estimate of the most probable amount of fallout) might be ten times greater than the AEC supposed. The article then calculates that the test "may raise the Sr^{90} levels in the fallout zone ["a swathe of sealing off the Cape Hope peninsula"] to anywhere from about 3 to 30 times their present levels." The article had earlier stated that it was also equally possible that fallout might be only

one-fifth the AEC estimate. This lower figure would make the range 1.4 to 30, but here, and in other parts of the report, the AEC figure for the most probable level is taken as the minimum level.

Using the factor of 10, the other major article makes rough estimates of the increase in strontium-90 in lichens (which accumulate strontium-90 very readily and which are the principal food of caribou) and in caribou. The report then discusses the possible increase in levels of strontium-90 in the 700 Eskimos living in the affected area, a major part of whose diet is caribou. No estimate of this increase is made, since, "although it can be predicted that fallout from the Chariot blast would increase the level of Sr^{90} in the diet of the region's Eskimos, no accurate estimate of the size of the effect can be made without additional information not yet available."

The article points out that there is not now enough information to make a judgment on whether there is any possible harm from the strontium levels involved, and suggests, therefore, a research program to supply the needed information.

The article concludes that "until the results of these studies are available, the great uncertainty about its possible effect on life is perhaps the most serious problem which stands in the way of a decision on the wisdom of setting off the Chariot explosion."

AEC officials complain that the report is neither as accurate nor as complete as the general public might suppose. They point out, for example, that the CNI assertion that the strontium-90 yield might be 10 times greater than the AEC believed likely was based on a misreading of an AEC-sponsored study. This study gave 5 percent as the most probable portion of the total radioactive yield that might get into the fallout.

Any technical errors, though, although they may prove embarrassing to CNI, do not affect the ultimate conclusions of the CNI report. The ultimate conclusion of CNI, as stated in a press release contrasting their report with the AEC's is that "the evidence, including the more extensive data cited in CNI's own report, is insufficient to support any firm conclusion regarding the safety of the project." This conclusion is not affected by the technical errors that may have crept into the report, and does not, for that matter, contradict the AEC report, which also did not reach any "firm conclusion."

The main problem with the CNI report is not with the technical soundness of the report but with the wording, and particularly the probable effect of the choice of words on the lay audience to whom the report was addressed.

CNI Conclusions

On one major conclusion CNI seems clearly misleading. The report states that "the fallout from the proposed explosion will add to the Sr^{90} levels by an *amount* which cannot now be estimated with any degree of precision" (emphasis added). This amount, of course, while difficult to predict precisely, falls within well-defined limits: it cannot be less than 0 percent nor more than 100 percent of the total strontium-90 produced by the explosion, and this latter figure can be predicted with good accuracy. But it also estimated that for the particular fallout constituent CNI was concerned with, strontium-90, the most probable figure would be 25 percent. Thus the figure could be underestimated, at most, by a factor of 4, not by the factor of 10 calculated by CNI.

Of the other two "general conclusions" cited earlier, the AEC agrees with that concerning the food chain. But the final conclusion, although accurate, could be misleading for the lay audience to whom the report is addressed. It simply says that "no firm prediction can be made regarding the ultimate harm that may result [from the test]" and that "according to the current philosophy of radiation protection, it is assumed that every increase in radiation exposure carries with it an increased risk of disease." This is perfectly true. Thus it is known that watching television exposes the viewer to small amounts of radiation, and in the words of the CNI report, "no firm prediction can be made regarding the ultimate harm," and again as the CNI report accurately points out, "it must be assumed that [this] increase in radiation exposure carries with it an increased risk of disease." As it happens, the exposure from habitual television watching, or from current levels of fallout, is roughly the same as the exposure the 700 Eskimos might receive if pessimistic assumptions about absorption of strontium-90 are correct. Although the ultimate harm cannot be firmly predicted, the National Academy of Sciences, in its widely respected report on radiation hazards, referred to the probable damage from such levels as "negligible."

A spokesman for CNI was asked whether the repeated emphasis on the difficulty of predicting the damage, if any, from such levels, along with the lack of any discussion of the range of damage within which uncertainty lies, might not mislead a general reader into thinking that the risks are much greater than any reputable scientist claims they are. The CNI spokesman said that "the idea of anyone interpreting the report in this way never crossed our minds," and that such information certainly would have been included if the committee had felt the report, as is, might mislead the public.

The CNI spokesman was asked whether the public, in evaluating the possible risks, might not have found useful some discussion of the likelihood that the damage would be great enough to be detectable. He said that an analysis of this problem would have made the report "too long," that the committee had attempted a calculation of probable damage but that it proved "too complicated," and that the committee had covered this subject, in any case, in other reports it had issued.

The CNI spokesman said he considered the report, as is, to be "a tremendous labor to give the scientist an idea of how he can function, and to give the public an idea of what the scientist can do for him."

The report (50 cents) is available from CNI, 6504 Delmar Blvd., St. Louis, Mo. The AEC report ($1) is available from the Office of Technical Services, Department of Commerce, Washington, D.C.—H.M.

The Test Ban

The general feeling is that the Administration has been handling the delicate problem of the disintegrating test-ban negotiations about as well as possible. What the Administration wanted to do, and appears to have succeeded in doing, was to make clear that the threat to resume testing was brought about by Russian intransigeance, rather than by an American desire to resume testing that outweighed our interest in reaching an agreement, or by a mere yielding to domestic political pressures.

The American "white paper" on the situation emphasized that it was the Russians who originally insisted that the test ban be separated from the

problem of general disarmament; that the West had offered significant concessions since the talks resumed in March, only to have the Russians step back from positions that had already been agreed upon; and that it was going to be extremely difficult to enter into the new kind of international relationships that seem to be required by the advent of nuclear weapons so long as the Russians insist on an unlimited concept of national sovereignty that makes a useful system of international law impossible to achieve.

Despite the vigorous tone of the white paper, as a policy statement it did not go beyond what both the Eisenhower and Kennedy Administrations have been saying for a long time: that the U.S. cannot permit the present unpoliced ban to run on indefinitely. The paper was primarily a criticism of Russia's uncompromising attitude. It did not assert that the U.S. *would* resume testing, and apparently no such decision has yet been made.

Space Discoverer Recovery

The Air Force soon may put a monkey in prolonged global orbit and attempt recovery as a result of the safe return and pick-up of its Discoverer XXV last Monday. The capsule had orbited the earth 33 times during a 50-hour ride in space.

Parachuting skin divers, all trained medical corpsmen, part of the 76th Air Force rescue squadron, recovered the 1-ton vehicle when it fell into the Pacific out of reach of Air Force planes standing by for an aerial catch.

The Air Force Discoverer program began 28 February 1959. It is an open-end research and development program aimed at perfecting a general-purpose space vehicle or "space truck" that can launch a variety of payloads.

The program has achieved, among other things, the first polar orbit; the first completely stabilized and controlled vehicle to be set in orbit and then redirected from ground controls; the first successful orbit and recovery of animals; the first aerial recovery of a space vehicle; and, now, the recovery at sea by parachuting skin divers.

If successful, the Air Force plan to recover a monkey after more than 2 days in space is expected to yield important information on the effects of weightlessness and on radiation.

Subversion and Education

Both the Senate and the House of Representatives are considering the question of subversion as it may relate to government loans for education.

The Senate Education Subcommittee has accepted President Kennedy's proposal to repeal the disclaimer affidavit provision in the National Defense Act of 1958. This provision requires a college student receiving a government loan to execute an affidavit disclaiming subversive beliefs and affiliations.

Twice during his terms in the Senate Kennedy tried to win repeal of the provision, but his efforts were unsuccessful.

In support of his legislation, Kennedy pointed out that several universities have refused to use the loans because of the loyalty and disclaimer requirements. If passed, his original bill would have removed both provisions. His present proposal does leave in the law the loyalty oath requirement for students. This is similar to the oath required of the President, and all those working in government, and most universities and colleges have found this less objectionable. The repeal of the disclaimer provision in the student loans, it should be noted, will not apply to students who may be recipients of fellowships and grants.

The American Legion has protested the Administration's proposal to drop the disclaimer affidavit, charging through Miles D. Kennedy, legislative director of the Legion, that those opposing the loyalty affidavit were waging "an active cold war of anti-Americanism." When asked by Representative John Brademas (D-Ind.) if he was accusing President Kennedy and former President Eisenhower, who had also opposed the provision, of being anti-American, the Legion official said he did not mean that they were un-American, but "they have been wrong before."

In the House, the Committee on Science and Astronautics opened hearings to investigate awards of fellowships and scholarships by the National Science Foundation.

The hearings were called at the request of Representative Richard L. Roudebush, a past national commander of the Veterans of Foreign Wars and a member of the House committee. He charged that the NSF was lax from the standpoint of security when it awarded a $3800 fellowship to a student convicted of contempt of Congress as a result of a hearing in 1958 before the House Un-American Activities Committee. The student, Edward Yellin, had refused to answer when asked if he was a Communist.

Roudebush, expressing shock and anger at the NSF grant to Yellin, said, "I think that there was not the necessary security exercised by the National Science Foundation. Greater security should be exercised whenever public funds are spent." He pointed out that the House Science Committee does have jurisdiction over the NSF grants by legislation as well as by House rule.

The House Science Committee, at its hearing, asked Alan T. Waterman, director of NSF, on what basis Yellin was awarded the grant, made in March of this year. Waterman said the law provides that the applicants are to be judged solely on ability. In response to the question whether the Foundation would have reached the same decision in approving the grant to Yellin if it had known of his conviction, Waterman said, "I believe so." Waterman and NSF counsel William J. Hoff said an applicant would be entitled to a fellowship, if he qualified on grounds of ability, regardless of a court conviction, whatever the grounds for the conviction might be. Several committee members said they felt that the law was deficient and should be changed.

Yellin had planned to use the grant to continue his engineering studies at the University of Illinois. He was recommended for the grant by Illinois faculty members, who may be brought for questioning before the House Science Committee, according to a statement by committee chairman Representative Overton Brooks (D-La.).

Yellin had based his refusal to answer the House Un-American Activities Committee query on the First Amendment to the Constitution. A staff member of the Un-American Activities Committee said, "This left him wide open to a contempt charge. If Yellin had pleaded the Fifth Amendment, no action could have been taken against him."

Upon his conviction in April 1960, Yellin was sentenced to a year in prison. The U.S. Circuit Court of Appeals upheld the conviction. Yellin now is carrying the appeal to the U.S. Supreme Court. In applying for the NSF grant, Yellin signed the disclaimer affidavit and took the loyalty oath.

Announcements

Grants, Fellowships, and Awards

Nominations are being accepted from AAAS fellows for the 1961 **Theobald Smith award**, for "demonstrated research in the field of the medical sciences" which shows independence of thought and originality. Any investigator who was less than 35 years old on 1 January 1961 and who is a citizen of the United States is eligible. The research is not to be judged in comparison with the work of more mature and experienced investigators. The award is given by Eli Lilly and Company under the auspices of the AAAS. Nominations must be received *before 1 September*. (Dr. Oscar Touster, Department of Biochemistry, Vanderbilt University School of Medicine, Nashville 5, Tenn.)

Postdoctoral research fellowships and grants to institutions in aid of **cardiovascular research** are being offered by the Life Insurance Medical Research Fund. Candidates desiring a postdoctoral research fellowship in any field of the medical sciences must submit applications *by 1 October*. Preference is given to those who wish to work on fundamental problems, particularly those related to cardiovascular function or disease. Minimum stipend is $4500, with dependency and travel allowances.

Applications from institutions desiring support for physiological, biochemical, and other basic work broadly related to cardiovascular problems as well as for clinical research in this field, will be accepted *until 1 November*. (Scientific Director, Life Insurance Medical Research Fund, 1030 E. Lancaster Ave., Rosemont, Pa.)

Twenty-five scholarships are available to academic personnel who wish to attend the **infrared spectroscopy** sessions and the **gas chromatography** session of the Fisk Infrared Institute, to be held at Fisk University from 23 August to 1 September. The awards, which were made possible by a grant from the National Science Foundation, cover tuition, room and board, and travel. The deadline for applications is *20 July*. (Director, Fisk Infrared Institute, Fisk University, 17th Ave. North and Jackson St., Nashville, Tenn.)

Scientists in the News

R. Elinor H. Judd, laboratory supervisor at the Robert Brigham Hospital Clinical Laboratories, has received the 1961 Corning award as the year's outstanding medical technologist in the United States. The award, given by the American Society of Medical Technologists, was presented at the annual meeting of the Society, in Seattle.

Four newly elected foreign associates of the National Academy of Sciences are as follows:

Keith E. Bullen, professor of applied mathematics, University of Sydney, Australia.

Boris Ephrussi, professor of genetics at the Sorbonne and director of the Genetics Laboratory at the National Center for Scientific Research, Gif-sur-Yvette, France.

Werner K. Heisenberg, director of the Max Planck Institute for Physics and Astrophysics, Munich, Germany.

Vladimir Prelog, professor of organic chemistry and director of the laboratory, Federal Institute of Technology, Zurich, Switzerland.

Ilmo Hela, director of the Institute of Marine Research, Finland, has been appointed chief scientist in charge of the newly established research program on the effects of radioactivity in the sea. The program will be conducted in Monaco under a trilateral agreement between the International Atomic Energy Agency, the Government of Monaco, and the Monaco Institute of Oceanography.

John C. Snyder, dean of the faculty of public health at Harvard, has been selected to be the university's first Henry Pickering Walcott professor of microbiology.

W. A. Deer, professor of geology at Manchester University, England, has been elected to the chair of mineralogy and petrology at Cambridge University, effective 1 October.

Robert W. Truitt, head of the department of aerospace engineering at Virginia Polytechnic Institute, has been appointed head of the department of mechanical engineering at North Carolina State College. He will be succeeded by **James B. Eades, Jr.**, professor of aerospace engineering at the institute.

Hans E. Hinteregger, physicist at Air Force Cambridge Research Laboratories' spectroscopic studies branch, has been presented the Air Force Meritorious Civilian Service award for his work in the field of ultraviolet radiation research.

K. R. Ramanathan, meteorologist with the Physical Research Laboratory, Ahmedabad, India, has received the International Meteorological Organization prize of the World Meteorological Organization.

Henry A. Hill, organic chemist and vice president of National Polychemicals, Wilmington, Mass., has been elected president of Riverside Research Laboratory, Cambridge, Mass.

J. A. Scanlan, associate professor of mechanical engineering at the University of Texas, has been appointed director of the university's new nuclear reactor laboratory, which is to be established next year.

Winston H. Bostick, head of the physics department at Stevens Institute of Technology, has been awarded first prize in the annual international competition of the Gravity Research Foundation.

Gilbert L. Woodside, dean of the graduate school and former head of the department of zoology at the University of Massachusetts, will become provost of the university on 1 July.

Alfred Novak, professor of natural science at Michigan State University, has been appointed chairman of the division of science and mathematics at Stephens College, Columbia, Missouri.

James R. Oliver, professor of chemistry at the University of Southwestern Louisiana, has been appointed dean of the university's graduate school.

Joseph L. Bernier, chief of the Army Dental Corps and professor of oral pathology at Georgetown University, has been elected a fellow of the British Royal Society of Medicine.

Lorin W. Roberts, assistant professor of botany at the University of Idaho, was recently named a Chevalier de l'Ordre du Mérite Agricola by the French Minister of Agriculture.

Book Reviews

Chemistry of the Amino Acids. vols. 1–3. Jesse P. Greenstein (deceased 12 Feb. 1959) and Milton Wintz. Wiley, New York, 1961. 2872 pp. Illus. $100.

These volumes represent a scholarly and complete but critical exposition of the organic and physical chemistry and the nutrition of the biologically important α-amino acids. The first two volumes deal with α-amino acids as a class of chemical compounds, and the third deals more specifically with the detailed history, reactions, synthesis, physical characteristics, and optical resolution of each individual amino acid and its more important derivatives. The subjects are developed historically and are brought up to the end of 1958 by extensive bibliographies which accompany each chapter. In addition to the intellectual development of the subjects, a large number of experimental procedures are illustrated, and enough technical details are provided to permit repetition in the laboratory.

The first two chapters deal with fundamental aspects of amino acids, such as their names and chemical structures, and with methods for their interconversion and for determining their absolute configuration. The significance of rotary dispersion curves of animo acids and of their copper complexes as a simple means of establishing configuration is emphasized, and theories of optical activity are presented. Amino acids in nutrition are traced from their early beginnings to their culmination in the classical contributions of W. C. Rose and his collaborators, which led to the isolation of threonine and to a clear distinction between dispensable and indispensable amino acids in man and in many other animal species. Many other related topics, for example, the parenteral feeding of amino acids and tissue culture, are discussed in a sufficiently comprehensive manner to provide a broad background for those interested in the more fundamental aspects of such subjects. Chapters 4 and 5 deal with amino acids as amphoteric electrolytes and as dipolar ions and with thermodynamics and solubility, respectively. The origin and significance of the various abbreviations used to designate dissociation constants and their interrelationships are clearly stated and should prove to be a boon, particularly to beginning students. The driving force of chemical reaction and the concept of free energy and its measurement and determination are presented with great clarity and should provide those without a background in physical chemistry a good perspective of the operation of these fundamental concepts. Chapter 6 reviews the importance of the coordinate covalent bond in amino acid, peptide, and protein chemistry; and chapters 8 and 9 provide discussions of the general and specific methods available for the synthesis and resolution of α-amino acids.

The highly advanced state of development of synthetic peptide chemistry is presented in fascinating detail in chapter 10 (volume 2). Over 39 of the synthetic procedures available to the biorganic chemist are treated extensively and critically. The tremendous activity and success in peptide synthesis is indicated by some 80 pages of tables which the authors have devoted to physical constants of acylated peptide esters, acylamino acids and peptides, and esters of unacylated peptides and by the bibliography of over a thousand references. Since illustrative procedures are provided for nearly every synthetic method mentioned, this chapter will be of great value to the experimentalist as well as to those interested only in reviewing the accumulated knowledge of peptide synthesis.

Included under the discussion of general analytical procedures (in volume 2) are nine chapters on colorimetric methods, manometry, and titrimetry; isotope dilution; microbiological assay methods; chromatography; sequential analysis of peptides; spectrophotometry; optical rotation; and determination of optical and steric purity. The historical development of each subject is used as a means of presenting the theoretical aspects, and each subject is brought up to date. A wealth of detailed information is included under each title, and the interested reader can obtain much information concerning the theory as well as the many significant applications of the methods concerned. In the discussion of sequential analysis of peptides, for example, proofs of structure are presented for the simple, naturally occurring peptides like glutathione and carnosine, and probable peptide sequences are given for a number of proteins such as silk, wool, and lysozyme. The Sanger and Edman procedures and their limitations for the characterization of N-terminal sequences are discussed when applied to insulin and to a number of other proteins including β-lactoglobulin, ovalbumin, bovine serum albumin, various hemoglobins, wool keratin, α-casein, papain, ribonuclease, carboxypepeptidase, and pepsin. Similar consideration is given to methods for determining C-terminal sequences, and the N- and C-terminal amino acids for many proteins are given in tabular form. The structure proof of insulin is given in detail, and sequence studies are also presented for many naturally occurring peptides such as phalloidin, the ergot alkaloids, tyrocidin, gramicidin, the bacitracins, corticotropin, glucagon, oxytocin, and vasopressin. In a similar way the detailed chemistry of several zymogens and the peptides released from them during activation are presented.

In chapter 20 of the second volume the authors are concerned with the enzymes used for optical resolution of the α-amino acids and their derivatives and with the determination of optical purity. Methods of preparation are given for renal acylase I, renal acylase II, pancreatic carboxypeptidase, renal D-amino acid oxidase, snake venom L-amino acid oxidase, bacterial decarboxylases, hepatic arginase, and renal aminopeptidase and for their respective use. In contrast to the measurement of optical rotation or of other physical properties of amino acids, it is clear that such enzymic procedures provide the only definitive methods by which amino acid steric purity of the order of 99 percent or better can be established with certainty.

The historical development, isola-

tion, structure proof, synthesis, resolution, methods of racemization, infrared spectra of the individual amino acids are treated in 21 different chapters of volume 3. Similarly, 11 chapters are concerned with the preparation of amino acids not known to be bound in proteins of mammalian tissue. The latter include aliphatic straight-chain monoaminomonocarboxylic, aminopolycarboxylic, diaminomonocarboxylic, diaminodicarboxylic, imino, α-alkyl amino, (β)-branched amino, α-amino-ω-hydroxy, sulfur-containing amino, ring-substituted α-amino, and N-alkylated amino acids. These chapters provide an exhaustive and authoritative survey of the several aspects of the amino acids mentioned.

In this review I have attempted to indicate briefly something of the subject matter and the thoroughness of its presentation. The more extensive and exhaustive the coverage of an important subject, the more likely is a short review to appear superficial and even trivial. However this may be in the present instance, it seems clear that these volumes will occupy an important place as a reference source for many specialists and for biochemists and biologists in general. The authors state in the preface that they "have been entranced by the spectacle of the many and diverse phenomena" associated with the behavior, properties, and biological duties performed by the α-amino acids. Biochemists and many others will benefit immeasurably because the authors were not only entranced but were highly discerning, skillful, and thorough in recording their extensive observations.

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The Physico-chemical Constants of Binary Systems in Concentrated Solutions. vol. 3, *Systems with Metallic Compounds*. xiii + 1322 pp. $36. vol. 4, *Systems with Inorganic + Compounds* (excepting metallic derivations). xi + 1332 pp. $39. Jean Timmermans. Interscience, New York, 1960.

With the appearance of volumes 3 and 4, this tabulation of the physical constants of concentrated solutions of two substances is complete. Volumes 1 and 2, which cover systems of two organic compounds, were reviewed in *Science* [**131**, 97 (1960)]. Volume 3 covers systems of two inorganic compounds, and volume 4 contains data on systems of one organic plus one inorganic compound, the references to the literature, and a 230-page formula index for the whole set.

The survey is noncritical and appears to cover the literature up to 1956. The bibliography is easy to use once the system of interest has been located in the tables. Finding a system is no easy task, however, for the only index provided is a formula index, and it is hopelessly inadequate. For example, under C_2H_6O appears the entry "ethyl alcohol" followed simply by about 200 page numbers that give no clue as to the nature of the second component. Under such circumstances the reader is practically forced to a page-by-page search through one or more of the thousand-odd page volumes to find specific data, if indeed they are present at all. Although the over-all organization ameliorates this situation somewhat, by no means do the volumes comprise a handy reference work.

While there is no doubt that this set will prove useful to specialists concerned with the properties of binary systems, poor indexing and the failure to evaluate discordant sets of data greatly diminish the value of the work for general reference purposes.

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Radiation Protection and Recovery. Alexander Hollaender, Ed. Pergamon, New York, 1960. v + 392 pp. Illus. $12.50.

Many efforts have been made to develop effective chemical and physiological-biological means to counteract the damaging effects of ionizing radiations. Often the situation appeared confused, the possibilities limited, practical applications doubtful. However, persistent work in the field has changed this picture. Today the multiplicity of approaches appears, in retrospect, more uniform than anticipated, and in the proper arrangement of the scientific facts an impressive inventory of the present state of the art can be presented. This is exactly what Hollaender does. The book's 12 chapters cover the protection of macromolecules and different biological systems, the experimental treatment of acute whole-body radiation injury in mammals, recovery phenomena, and photo-reactivation. The stimulation given to biology and medicine—for example, Lorenz's classical bone marrow experiment and its implications to tissue transplantation techniques, to immunological problems and related phenomena—becomes obvious.

Historical remarks, cleverly inserted, vivify the presentation; their value might have been increased by more detailed consultation of the reports of the Atomic Energy Commission and other governmental agencies—for example the protective action of cysteine on the synthesis of desoxyribonucleic acid in the intestinal mucosa of x-irradiated rats was reported in 1952, long before rediscovery of the effect in 1958. But perhaps it is such facts that make reading the book so interesting. The volume stimulates and it challenges. The pioneer in the field starts to revise old and to look for new ideas and interpretations; the newcomer accepts gratefully the tremendous background information presented by the different contributions and so well selected by the editor.

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Handbook of Microbiology. Morris B. Jacobs and Maurice J. Gerstein. Van Nostrand, Princeton, N.J., 1960. x + 322 pp. Illus. $8.50.

Compiled from contemporary literature and arranged in 38 alphabetically organized, so-called "tables," this book provides data for professional work in microbiology. Although it attempts a broad coverage of bacteriology, there is little on viruses, and protozoology per se is omitted. The 150-page, first table, which describes 160 species of bacteria, leaves out several important species—for example, *Salmonella paratyphi* and *Haemophilus ducreyi*—and includes a few of slight importance—for example, *Spirillum volutans* and *Pseudomonas ovalis*. Synonyms should have been included, and space could have been saved by a different arrangement: more than 30 lines are used for the fermentation reactions of *Acetobacter aceti*.

The classes, orders, suborders, families, and genera of bacteria, rickettsia, and viruses according to *Bergey's Manual* (1957) are listed, but I see no need for including Krassilnikov's classification (1949). Table 6 allots 21

pages to 260 antibiotics. Mitomycin gets 64 lines, bacitracin a third as much, and there are 10 lines for tetracycline. Table 15 gives the phenol coefficients against *Salmonella typhosa* and *Staphylococcus aureus* for nearly 400 substances. There are brief descriptions of 130 culture mediums and of 76 microbiological reagents and tests, and 12 pages are devoted to 105 stains. There are also temperature conversion tables, tables of most probable numbers, and a listing of *Shigellae* and *Salmonellae* serotypes. Four tabulations outline bacterial, viral, and rickettsial diseases. Nine small tables deal with such subjects as the differentiation of *Neisseria* species. Toxins, antitoxins, and antisera and toxoids and vaccines are characterized in Tables 20a, b, and c. The last table diagrammatically illustrates four methods for preparing "test dilutions," a rather elementary note on which to end. The lack of a general index makes the book less useful. The volume contains surprisingly few errors for a first edition and is a useful book, but it is hardly a "handbook," in the old German sense.

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Physics and Archeology. M. J. Aitken. Interscience, New York, 1961. x + 181 pp. Illus. $6.

Archeologists are unusually fortunate in being able to capitalize on the researches of scholars in other disciplines, and this book ably summarizes some of the ways in which the techniques of physics can be applied to the solution of archeological problems. The author deals primarily with two fundamental facets of research: the finding of archeological remains and the dating of such finds. A final chapter is concerned with the physical and chemical analysis of specimens.

The finding of sites utilizes aerial photography (mentioned briefly) and instruments that recognize variations in remanent magnetism and in electrical resistivity of soils. These instruments (including the proton magnetometer) are particularly useful for finding individual features within a site, such as filled ditches or graves, buried floors, and ancient pottery kilns. Although such scientific detection methods have been proved effective in many cases, they are still in their exploratory phases, and only a minority of archeologists have actually made use of them. This is partly because many archeologists have not yet acquired the instruments or learned how to use them and partly because problems in application sometimes defeat the techniques. As the author points out, buried horseshoes or natural pockets of moisture in the ground can register as strongly as the sought-for archeological features. However, these techniques will no doubt be more widely used in the future because they can certainly reduce the amount of expensive hit-or-miss digging now necessary in archeological sampling.

One chapter is devoted to the now well-established method of radiocarbon dating, and another to the somewhat less satisfactory techniques of magnetic dating; several other techniques for dating are mentioned briefly. The discussions are admirably organized, lucid, and informative; the author has successfully presented the facts without requiring the reader to have a specialist's knowledge to understand them.

One interesting example, in the final chapter (on analysis), is the use of chemical dating in analyzing Roman coins of the first two centuries A.D. These coins show a steadily decreasing zinc content, apparently due to loss of zinc when old coins were melted down and reused to make new ones. This example typifies the search for dating techniques—any measurable regularity through time is of potential value to archeology, for time is the archeologist's stock in trade.

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Scientific and Technical Societies of the United States and Canada. NAS–NRC Publ. 900. Compiled by John H. Gribbin *et al.* National Academy of Sciences–National Research Council, Washington, D.C., ed. 7, 1961. 512 pp. $9.

An alphabetically arranged list covering 1836 professional and selected amateur societies in scientific and technical fields: Part 1 lists 1597 in the United States; part 2, 239 in Canada. Information provided about each society is concerned with its officers, history, purpose, membership, professional activities, and the like. Periodicals published by the societies as well as the names of their medals, prizes, awards, and lectures and trusts are indexed.

Living Fishes of the World. Earl S. Herald. Doubleday, New Yo.k, 1961. 304 pp. Illus. $12.50.

This handsome volume reflects the broad background of a professional ichthyologist who has become intimately acquainted with many of the species about which he writes through his experience as director of Steinhart Aquarium and through field work in areas richly endowed with fish. To those who have not yet joined the growing ranks of skin divers, particularly along tropical shores, the kaleidoscopic natural colors in the 145 magnificent color plates may seem incredible. The beauty of the plates is greatly enhanced by artistic choice of backgrounds and by numerous interesting poses, closeups, and habitat shots.

After a brief introduction, Herald's discussion of fishes, which follows along systematic lines (essentially Regan's classification), ranges from the primitive jawless hagfishes and lampreys through the sharks and their allies to the so-called bony fishes (which include the majority of living species, approximately 15,000 to 20,000 kinds). He stresses groups less often treated in popular aquarium books. Characteristics, habits, range, and life history information are covered, and they yield such interesting facts as the use of "sonar" by African elephant fishes, the practice of intestinal respiration by Asiatic loaches, the maturing as functional females of certain sea basses that later reverse their sex to become functional males, and the "cleaning" of ectoparasites from large fishes, chiefly by small wrasses (illustrated in plates 27 and 98). Plates 80 and 83 show the striking sex dichromatism that occurs in the male and female of the same species of parrotfish (page 204).

Professional ichthyologists (for whom the volume was not written) may be mildly upset by the use of the terms "ventral" and "tail" fins, especially since many other technical terms are used. Some misstatements are inevitable in a work of this scope, and misspellings have crept in, but such minor discrepancies can be easily corrected in a re-

vised edition. The not infrequent wide separation of text reference and color plate could be avoided by a page reference to assist the reader.

There is a brief glossary, a bibliography, and an index. The author, the photographers, and the publisher are to be congratulated for producing a work that is well worth its purchase price.

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Radiation Damage in Solids. Douglas S. Billington and James H. Crawford, Jr. Princeton University Press, Princeton, N.J., 1961. xi + 450 pp. Illus. $12.50.

In recent years it has become increasingly apparent that many of the most useful and striking properties of solids depend directly or indirectly upon the presence of imperfections in the crystalline lattice, that is, upon the defect structure of the solid. Dramatic changes may occur in the physical properties of materials subjected to energetic irradiation, because of the production of defects. Unfortunately for nuclear technology, such effects are particularly pronounced in fissile materials. In other engineering applications, as well, new and stringent requirements on defect structure have arisen for solids for use as structural materials at very high or very low temperatures or for use as complex electronic circuit components. The availability of very intense sources of energetic radiation which facilitate controlled investigation of the crystalline defects thereby produced has therefore encouraged the study of these crystal defects for their own sake.

Billington and Crawford, long associated with fundamental studies, primarily in neutron damage, at Oak Ridge National Laboratory, have set down a comprehensive yet compact account of the whole field of radiation effects studied by physicists and metallurgists. Included in this volume are accounts of the effects in metals, alloys, minerals and glasses, ionic crystals, semiconductors, and even in those particularly perverse substances uranium and graphite. Reference is made to the work, through 1959, of nearly 600 scientists.

Many useful criticisms and evaluations of the work discussed are incorporated. The authors have not hesitated to include impartial accounts of conflicting studies in which final judgments cannot yet be reached, but occasionally they have not been ruthless enough to leave out some work which is muddled or which defies comparison with other investigations.

The treatment is well adapted to the needs of one who is considering, doing, or interpreting experimental work on radiation damage or lattice imperfections. Three introductory chapters present the essential results of existing calculations of the inelastic interactions of radiation with solids as well as of important secondary effects, an outline of the influence of lattice imperfections on the properties of solids, and a critical and practical discussion of radiation sources suitable for damage studies.

As might be expected in a growing field, progress in obtaining unambiguous experimental results and in understanding them has been startlingly precise in some cases and depressingly incomplete in others. Understanding of a broad range of effects has now been reached in a qualitative and phenomenological manner.

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New Books

Biological and Medical Sciences

The Actinomycetes. vol. 2, *Classification, Identification and Descriptions of Genera and Species.* Selman A. Waksman. Williams and Wilkins, Baltimore, Md., 1961. 372 pp. Illus. $15.

Advances in Blood Grouping. Alexander S. Wiener. Grune and Stratton, New York, 1961. 561 pp. Illus. $11.

Annual Review of Medicine. vol. 12. David A. Rytand and William P. Creger, Eds. Annual Reviews, Palo Alto, Calif., 1961. 462 pp. $7.

The Bacteria. A treatise on structure and function. vol. 2, *Metabolism.* I. C. Gunsalus and Robert Y. Stanier, Eds. Academic Press, New York, 1961. 587 pp. $15.

Biology and Comparative Physiology of Birds. vol. 2, A. J. Marshall, Ed. Academic Press, New York, 1961. 478 pp. Illus. $14.

Cell Function. An introduction to the physiology of the cell and its role in the intact organism. L. L. Langley. Reinhold, New York; Chapman and Hall, London, 1961. 389 pp. Illus. $7.50.

Communication among Social Bees. Martin Lindauer. Harvard Univ. Press, Cambridge, Mass., 1961. 152 pp. Illus. $4.75.

Diagnostic Cytology and Its Histopathologic Bases. Leopold G. Koss. Lippincott, Philadelphia, Pa., 1961. 393 pp. Illus. $16.50.

The Doubleday Pictorial Library of Nature: Earth, Plants, Animals. Josephine Perry, Ed. Doubleday, New York, 1961. 359 pp. Illus. $9.95.

Elements of Zoology. Tracy I. Storer and Robert L. Usinger. McGraw-Hill, New York, ed. 2, 1961. 472 pp. Illus. $7.25.

Explorations into the Nature of the Living Cell. Robert Chambers and Edward L. Chambers. Harvard Univ. Press, Cambridge, Mass., 1961. 376 pp. Illus. $8.

Francis Walker's Aphids. John P. Doncaster. British Museum (Natural History), London, 1961. 172 pp. Illus. £3.

Functional Anatomy, Mammalian and Comparative. W. James Leach, McGraw-Hill, New York, ed. 3, 1961. 346 pp. Illus. $6.50.

Growth, Development, and Pattern. N. J. Berrill. Freeman, San Francisco, Calif., 1961. 560 pp. $10.

The Human Cerebellum. An atlas of gross topography in serial sections. Jay B. Angevine, Jr., Elliott L. Mancall, and Paul I. Yakovley. Little, Brown, Boston, Mass., 1961. 147 pp. Illus. $15.

Intermediary Metabolism in Plants. David D. Davies. Cambridge Univ. Press, New York, 1961. 120 pp. Illus. $4.

Macromolecular Complexes. M. V. Edds, Jr., Ed. Ronald, New York, 1961. 263 pp. Illus. $7. Proceedings of the symposium sponsored by the Society of General Physiologists, September 1959.

Manual of Clinical Bacteriology. Alexander Kimler, Lippincott, Philadelphia, Pa., 1961. 214 pp. $4.75.

Mechanical Measurements. T. G. Beckwith and N. Lewis Buck. Addison-Wesley, Reading, Mass., 1961. 573 pp. Illus. $8.75.

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The Iranian Prehistoric Project

New problems arise as more is learned of the first attempts at food production and settled village life.

Robert J. Braidwood, Bruce Howe, Charles A. Reed

Abstract. Many indications point toward the hill flanks of the Fertile Crescent in southwestern Asia as the scene of the earliest development of effective food production and a village-farming-community way of life, some 10,000 years ago or less. In its 1959–60 field season, with a staff made up of both cultural and natural historians, the Iranian Prehistoric Project reclaimed further evidence of this important transitional step in human history. This is a short interim report, based entirely on an in-the-field assessment of the materials.

The Iranian Prehistoric Project (*1*), with essentially the same senior staff as that of the old Iraq-Jarmo projects (*2*, *3*), spent a field year in the intermontane valleys of the Zagros Mountains near Kermanshah in Iran, from September 1959 through June 1960. The expedition's field collections reached Chicago late in 1960, and work on the processing and interpretation of these materials is now beginning. The goal of this expedition, as of the previous ones, was the reclamation and interpretation of evidence for the earliest appearance of an effective food-producing and village-farming-community way of life.

Various circumstances dictated the shift from the somewhat lower valleys (about 2500 feet) of essentially the same environmental zone in Iraqi Kurdistan (*2*, pp. 9–17, 25–31) to the valleys of Shahabad, Mahidasht, and Kermanshah, at an elevation of about 4500 feet and extending from about 33°45′N to 34°45′N and from 46°15′E to 47°15′E. Since the prehistory of this part of Iran was largely unknown, we commenced our field season with a surface survey for both caves and open-air sites, and we maintained some survey activity until the late spring of 1960. Over 250 prehistoric sites were thus located, and their surface materials were tentatively classified into eight rough chronological groups or models (*4*), which must represent—in a very general way—a time span of culture history from about 100,000 years ago to about 5000 years ago. Sites yielding surface materials suggesting the time range from about 15,000 to about 8000 years ago—the interval during which the swing to effective food production and village-farming communities must have occurred—were well represented, and several of these were selected for excavation in the spring of 1960.

The rock shelter called Warwasi, about 12 km northeast of Kermanshah, yielded a sequence of flint industries from a phase of the Mousterian through a sequence of blade tools which included both Baradostian and Zarzian levels. On the basis of the field classification of these materials alone, there is reason to suspect little typological disconformity in this developing sequence, which probably ends at about 10,500 years ago.

Asiab

A small low mound called Asiab, overlooking the Kara Su river about 6 km east of Kermanshah, yielded a flint industry probably contemporary with, although hardly an exact technotypological counterpart of, the Karim Shahirian of Iraqi Kurdistan. There are some coarser, ground-stone artifacts in the Asiab assemblage, also beads, pendants, and bracelet fragments of marble, and numerous small clay objects, including a few enigmatic figurines. Roughly one-quarter of a large more-or-less round and shallow basin appeared (estimated diameter, about 10 m), perhaps the floor of some kind of semisubterranean structure. Two red-ochre-stained burials, many animal bones, and great quantities of river clams, but virtually no land snails, were found at Asiab.

For Near Eastern prehistory at least, the exceptional find at Asiab was great quantities of what we interpreted to be coprolites. Should these indeed prove to be coprolites and to be human, they will be an invaluable clue to the diet of a group of people who had already achieved a somewhat settled way of life on the basis of intensified regionalized food collecting, and who also should have been on the road to "incipient agriculture." These objects we are calling coprolites are definitely of the size and shape of human coprolites, and they occur in great concentrations within the living area at Asiab, which circumstance also would indicate a human origin. Coprolites of wild animals would not be expected to occur there, and we have no evidence for domestic animals at Asiab.

Pending future radioactive-carbon determinations, our suggested date for Asiab is somewhere between 11,000 and 9000 years ago, in general conformity with the C^{14} determination for the similar cultural stage recorded at Zawi Chemi Shanidar in Iraqi Kurdistan (*5*).

Sarab

At another low small mound, called Sarab, which lies about 7 km east-northeast of Kermanshah, an assemblage of prehistoric materials was excavated which, in part, strongly recalls artifactual elements of the village-farming-community assemblage at Jarmo in Iraqi Kurdistan. In fact, the pottery, the clay figurines, the finer work in ground stone, and the flint and obsidian industries might be said to be typological advances over their Jarmo counterparts within the same general technological traditions. But in contrast to Jarmo (which had rather well built,

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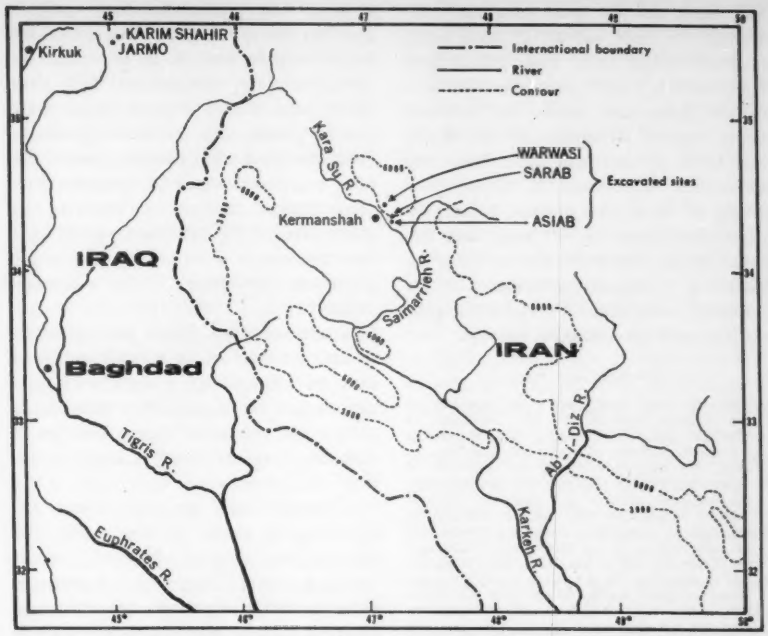
rectilinear, mud-walled houses of several rooms), Sarab appears to have had very informal, semi-pit structures at best (perhaps with reed-covered roofs), and the site does not give the impression of year-round permanency, as did Jarmo. Nor have we yet firm indications of the presence of wheat or barley, an important element of the Jarmo assemblage, although it is possible that traces of these cereals may yet appear as molds in lumps of earth (*6*). The site did yield many animal bones, and the field identifications gave firm indications of the presence of domesticated goats at least, a standard element at Jarmo (*7*). Also, as at Jarmo, there was a great concentration of shells of a local land snail, *Helix salomonica*, undoubtedly gathered for food. A smaller number of "coprolites" also appeared on Sarab.

But Sarab does not, it seems, fit the theoretical picture of an early village-farming community nearly as neatly as did Jarmo. Hence it raises some very interesting problems of culture history and problems regarding prevailing theory as well. Until counts of the Sarab radiocarbon samples have been made, our guess is that the site must date to about 9000 to 8000 years ago.



The Iranian Prehistoric Project: During the 1959–60 field season the project's expedition excavated three sites, Warwasi, Sarab, and Asiab, near Kermanshah, in search of evidence on the development of village farming communities by early man. The new sites are south and east of the previously excavated sites at Jarmo and Karim Shahir (top left), in Iraqi Kurdistan. [Based on a U.S. Air Force long-range navigation chart, 1:3,000,000]

Natural Scientists in the Field

From January 1960 onward, the natural scientists on the expedition staff joined the field party. Charles A. Reed (University of Illinois), zoologist, continued his collections, particularly of the Mammalia, begun in Iraqi Kurdistan in 1954–55, and he also was in charge of the osteological materials from the various excavations. Herbert E. Wright (University of Minnesota), geologist, concentrated during this field season on the collection of pollen cores; he reports, as his laboratory studies begin, that the prospects for an assessment of the climatic patterns of the area are very good. Wright and his graduate assistants were also able to take samples in several other parts of the Near East. Jack R. Harlan (Oklahoma State University and U.S. Department of Agriculture), botanist, collected broadly (with emphasis on the cereals), secured samples from the excavations, and, at the end of our field season, continued his collecting eastward into Afghanistan, Pakistan, and India, returning in February 1961, via Abyssinia. Harlan has passed on to us his in-the-field impression that, as far as the ecological situation in Asia is concerned, the locale for the effective domestication of the wheat-barley cereals does not lie east of Kurdistan.

As the "coprolites" began to appear at Asiab, Hans Helbaek (Danish National Museum), paleoethnobotanist, was once more able to rejoin the staff for a fortnight. Frederick R. Matson (Pennsylvania State University), specialist in technological history and preparational techniques, arrived later in the spring and undertook further detailed ceramic studies, collected raw clays, secured radiocarbon samples from the various sites, and did one short sounding excavation of a later prehistoric site, as did Cornelius Hillen (Middle East Institute, Rotterdam). For a short while, also, we were joined by Albert A. Dahlberg (University of Chicago), dental anthropologist, who undertook examinations of human teeth, both from the excavations and of the contemporary inhabitants. Dahlberg is interested in the possibility that both the conformation and the wear of teeth may reflect the dietary change which must have accompanied the appearance of food production. Finally, functioning as an ethnologist throughout the year, Patty Jo Watson (University of Chicago) undertook studies of the contemporary villages of the area, especially from the point of view of their material goods and agricultural routine.

Preliminary Conclusions

Since the laboratory processing of the materials is only now under way, it is too early to speak of absolute results. Our immediate post-field impression does include a feeling that the Kermanshah valleys *may* lie slightly too high to have been in the optimum part of the environmental zone for utilization, by incipient agriculturists, of the potential plant and animal domesticates. Further, with respect to the origin of food production, while our field work so far certainly does not incline us toward explanations which link postulated climatic fluctuations with early food production in a causative sense (*2*, p. 175), we are bearing in mind recent suggestions (*8*) that an abrupt climatic swing occurred about 11,000 years ago.

It is true that the now desiccated stretches of the Zagros hill flanks, at elevations from about 1000 to 2500

feet, have not yet been adequately examined. A new survey is now being planned which will link the higher Kermanshah valleys with the alluvium of the Khuzestan plain, by traverses along various tributaries of the Karkheh River. *If* incipient agriculture had its earliest beginnings at these lower levels, to be shifted upslope rather abruptly just after 11,000 years ago because of an onset of desiccation, the traces of "incipient" settlements at the lower altitudes should certainly appear during such an intensive survey.

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1. These projects have been joint ventures of the Oriental Institute of the University of Chicago and the Baghdad School of the American Schools of Oriental Research. In Iran, we were joined by the Institute of Archeology of the University of Teheran. The projects have received aid from the National Science Foundation (for the participation of the natural scientists), from the department of anthropology of the University of Chicago, the Penrose Fund of the American Philosophical Society, the Wenner-Gren Foundation for Anthropological Research, and (for Dr. Dahlberg) the U.S. Public Health Service. In Iran we benefited from the interest and aid of the Iranian Government's Antiquities Service, the National Iranian Oil Company, the Khuzestan Development Service, the Kampsax Engineering Company, and interested Iranian and American officials, missionaries, and private citizens. Robert J. Braidwood served as general director of the project for the University of Chicago; Bruce Howe (Peabody Museum, Harvard University), as associate director, represented the American Schools; and Ezat O. Negahban served for the University of Teheran.
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24 March 1961

Electrophoretic Analysis of Immobilization Antigens of Paramecium aurelia

Abstract. The isoelectric points of the immobilization antigens A, B, and D of strain 51 of *Paramecium aurelia* (variety 4) have been determined to be 4.0, 3.9, and 4.3, respectively.

When paramecia are placed in homologous antisera, an immobilization reaction takes place which may result in the death of the animals if they are exposed to sufficiently high concentrations. Beale (*1*) and Preer and Preer (*2*) have demonstrated that the immobilization antigens are associated with the cilia and body wall. Preer (*3*) has isolated the immobilization antigens and has shown that they constitute the major soluble protein in the cilia. Investigations by Sonneborn (*4*) have shown that within a given strain there can be produced a series of alternative serotypes whose individuals contain one of a number of specific antigens. Previous genetic analysis has revealed the interaction of the cytoplasm, genes, and environment in determining the antigen expressed [see Beale (*5*) for a detailed review].

Transformation from one serotype to another may occur spontaneously or may be induced by a variety of conditions (*4*). It is, however, possible to obtain and maintain large quantities of animals of a pure serotype under specified conditions.

Although each serotype within the homozygous strain 51 may readily be distinguished serologically, certain cross reactions occur. Preer (*6*) has reported the occurrence of groups into which the antigens may be placed dependent upon their cross reactions. For example, 51 A and 51 B show a weak cross reaction, while neither cross reacts with 51 D.

In light of the genetic control over antigen production and specificity, it is of interest to gain an understanding of the structural differences that exist on a molecular level as a direct reflection of the differences that exist among the respective genes. This report is concerned with the electrophoretic properties of the proteins as the first step in characterizing chemically the structural differences between certain of the immobilization antigens which can be produced by the homozygous strain 51.

The electrophoretic behavior of the immobilization antigens A, B, and D of strain 51 of *Paramecium aurelia* (variety 4) was studied with a Perkin-Elmer model 38 Tiselius apparatus. The electrophoresis buffers employed in all runs were 0.1 ionic strength and were prepared by the method described by Miller and Golder (*7*) with a *p*H range of 2.6 through 11.5. The specific antigens were isolated by Preer's technique (*3*). In order to facilitate comparison, mixtures, rather than the individual proteins were subjected to electrophoresis. Mixtures were prepared so that they consisted of two parts of A and one part of B; other mixtures consisted of two parts of A and one part of D. One component was made twice as concentrated as the other to aid in identification. Identification was confirmed by taking samples from their respective zones in the Tiselius cell and identifying them serologically.

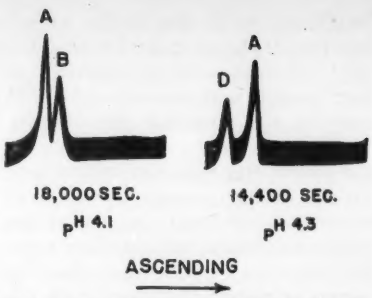

Fig. 1. Tracings of the ascending electrophoretic patterns of 2:1 mixtures (stock 51) of antigens A and B, and A and D, respectively.

Figure 1 represents tracings of the electrophoretic patterns of mixtures of A and B, and A and D. Mobilities were calculated, and complete curves for A and D appear in Fig. 2. The isoelectric points of A, B, and D were determined to be 4.0, 3.9, and 4.3, respectively. The isoelectric point of antigen A is in agreement with the estimate made by Preer from paper electrophoresis (*8*).

Antigens A and B separated only after prolonged electrophoresis at *p*H values near their respective isoelectric points, demonstrating a close similarity in their net charges. This similarity is reflected by the closeness of their isoelectric points. A and D, on the other hand, showed separation at all *p*H values run between 2.6 and 11.5. The electrophoretic behavior parallels the ammonium sulfate solubilities and immunological relationships reported by Preer (*7*). As previously mentioned, antigens A and B cross react, while neither shows any cross reactivity with antigen D. Antigens A and B possess the same ammonium sulfate solubility, while antigen D exhibits a higher ammonium sulfate solubility.

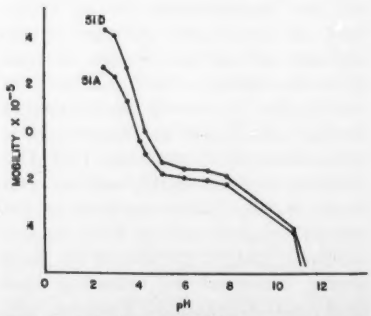

Fig. 2. Calculated mobility curves for antigens 51 A and 51 D.

Bishop and Beale (*9*) working with variety 1 of *P. aurelia*, have reported different electrophoretic mobilities on starch gel for three different isolated antigens, G, D, and T.

The differences in immunological relationships, ammonium sulfate solubilities, and isoelectric points suggest that the antigens differ in their amino acid sequence. However, the possibility that the variations result only from differences in the gross pattern of folding cannot be ruled out. Studies designed to settle this point are now being undertaken. It is hoped that light will be shed on the general problem of the genetic control of protein specificity (*10*).

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10. This work was aided by grants to J. R. Preer from the Phi Beta Psi sorority. I wish to acknowledge the support of J. R. Preer, and the assistance of S. D. Rodenberg in connection with certain of the technical procedures.

20 February 1961

Excitation and Inhibition of Neuronal Firing in Visual Cortex by Reticular Stimulation

Abstract. The frequency of action potentials of about one-third of the neurons sampled in the striate cortex of awake rabbits was clearly modified by mild stimulation of the reticular core of the brain stem. Reticular stimulation often brought about enhancement of firing in units activated by light, while it usually had the contrary effect upon light-inhibited units.

A behavioral study (*1*) has demonstrated that the threshold of tachistoscopic discrimination can be lowered by electrostimulation of the brain-stem tegmentum, thus indicating that reticular activation facilitates some central process of vision. The purpose of the present investigation (*2*) was to study how reticular activation affects single neurons in the visual cortex. In acute experiments, these cells have already been shown to be influenced by stimulation of diffuse projection nuclei of the thalamus (*3*). However, the use of chronic animals is more desirable for such investigations than the use of any kind of acute preparation, in which lesion of tissues or the action of some drug may obscure effects attributable to the experimental variables.

The experiments were performed on New Zealand white rabbits. Steel microelectrodes, made according to Green's technique (*4*), were utilized for recording action potentials of single units. Each animal was surgically prepared under anesthesia, at least 1 day before any experiment. A tubular steel implant, fitting in a trephine hole in the skull, was cemented to the bone after the underlying dura had been removed. Two electrodes for stimulation were introduced through another hole and implanted in the mesencephalic tegmentum. The skin was sutured around the electrode leads and the metal implant. The lumen of the latter was filled with warm mineral oil and sealed with a threaded cap.

For an experimental session the animal was put in a hammock, and the mineral oil in the implant was replaced by a 4-percent solution of agar at 40°C which solidifies at body temperature, thus eliminating respiratory movements of the brain. To drive a microelectrode for recording, a special hydraulic micropositioner, resembling in some features the one developed by Hubel (*5*), was used (Fig. 1). A hollow adapter, screwed to the implant, is the base to which a nylon cylinder is fastened. The microelectrode is set in the center of a nylon piston riding inside and is electrically coupled to the input of an amplifying system through a cathode follower. A vent in the side of the adapter maintains the space between piston and agar at atmospheric pressure, while the cylinder is filled with oil above the piston and connected to a micrometer-syringe by polyethylene tubing. When the syringe is advanced, the microelectrode tip traverses the agar and penetrates the cortex. The preparation permits repeated punctures in each animal for a number of days.

Diffuse binocular light was used (about 1070 lux at the corneas), lasting 1 sec or more. The animals, with eye atropinized, were in the dark between stimuli. Reticular stimulation was applied in trains, usually 250 msec long, of 300-cy/sec pulses. Intensity, normally ranging between 50 and 150 μa, was always chosen so that it was insufficient to cause any kind of motor reaction. The position of all brain-stem electrodes was histologically verified.

One hundred units of the striate cortex were studied. It is assumed that the majority of records were extracellular and of cell-body spikes. The spontaneous rate of unit impulses varied considerably, ranging from 0 to 54 spikes per second, but most units exhibited slow (median, 1.47 spikes per second) and irregular firing. Grouped or clustered activity was seen, though it was far less common than it is in thalamic units under the same experimental conditions (*6*). According to their reactions to light, all units were classified as Jung *et al.* have done with cortical cells in the cat (*7*): 13 units showed an increment of firing rate at the onset of illumination (B-type of Jung); 14 were inhibited at the "on" of the light and showed an "off" discharge (D-type); and 21 other units reacted with increments of discharge both at "on" and "off" of the light (E-type). One-half of all units did not show any definite reactions to long dif-

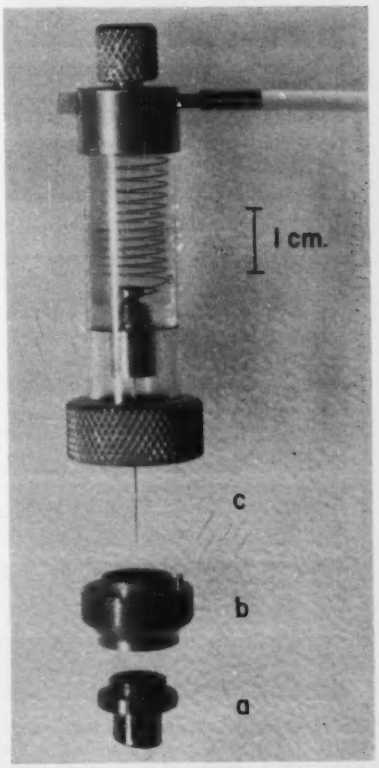

Fig. 1. Micropositioner. (*a*) Implant; (*b*) adapter; (*c*) microelectrode. The aluminum top of the cylinder is connected to the input.

fuse illumination (A-type). These units were not completely unresponsive to light, but their reactions were extremely inconstant and weak; some of them, while not responding to long light stimuli, did respond to brief flashes of higher intensity. Only two units were found to be inhibited at "on" and "off" of the light (C-type). Some units responded to moving luminous spots in the visual field, as Hubel has seen in cortical neurons of the cat (*5*), but responses of this kind were not explored systematically.

Sixty-one units were unaffected by stimulating the brain stem, but the rest showed clear frequency changes in response to this stimulus, and the effects persisted for some time after its cessation. The firing of 14 units was accelerated, while that of 25 others was slowed down by reticular stimulation alone. Although there were exceptions, it was observed that light-activated units tended to be accelerated by the reticular stimulus, whereas units showing light inhibition tended to be likewise inhibited by the reticular stimulus (Fig. 2). In many such cases light and tegmental stimulation, when applied simultaneously, interacted with each other in mutual reinforcement. The majority of those units which did not respond to light were not affected by reticular stimulation. Discharges induced by darkness, prominent in most D- and E-units at the cessation of light, were in some instances enhanced and in others inhibited by brain-stem stimulation. No correlation was found between cortical depth and types of response to either light or electrical stimulation.

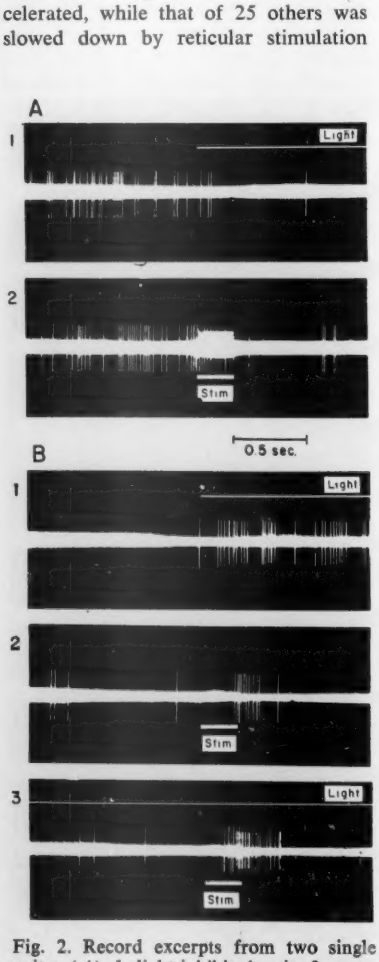

Fig. 2. Record excerpts from two single units: (*A*) *1*, light-inhibited unit; *2*, same unit in dark, inhibited by reticular stimulus. (*B*) *1*, light-activated unit; *2*, same unit activated by reticular stimulus alone; *3*, same unit, reticular stimulus during light. Records read from left to right.

This study demonstrates that reticular activation can result in excitatory or inhibitory modulation of certain neurons in the striate cortex. Furthermore, it shows that this modulation acts in many instances synergically with luminous stimuli, although more work is needed to determine how this synergism is accomplished. Since both excitatory and inhibitory synaptic effects have been demonstrated in cortical cells by stimulation of the lateral geniculate body (*8*), it is possible that the reticular influences reported here are exerted upon presynaptic neurons at the geniculate or intracortical levels.

It has been postulated (*1*) that the same basic process that secures arousal from sleep—that is, the generalized activation of the cortex by the reticular core of the brain stem—is responsible in the awake organism for the attainment and maintenance of states of high receptivity of the sensory cortex. Thus, such a mechanism might underlie a descent of sensory thresholds in behavioral alertness. Some support for this postulate is provided by the fact that reticular activation, experimentally elicited, has differential effects upon various visual cortical cells according to the characteristics of their responses to optic stimuli. It is recognized that these characteristics are determined by the nature of the receptive fields of the individual units, the spatial configuration of stimulus intensities, and other possible factors which account for the complexity of the cortical representation of visual patterns.

The probably ubiquitous character of reticular activation upon sensory areas does not preclude the existence of more specialized processes, perhaps corticothalamic, conceivably operating to channel reticular tonus, and that may be at the basis of selective focusing of attention.

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13 February 1961

Auxetic Growth in the Javanese Toad, Bufo melanostictus

Abstract. Morphologically, it has been found that erythrocyte size in the Javanese toad is greater in large than in small animals, and preliminary data indicate that the same is true of kidney, intestinal, and liver cells. Physiologically, the hemoglobin concentration, packed cell volume, specific gravity of the whole blood, and the liver glycogen concentration also increase with the size of the animals.

One of the advantages of working with tropical amphibians on Java springs from the fact that the unchanging climatic factors, especially temperature and humidity, and the unending food supply, make it possible for them to maintain constant reproductive and physiological conditions throughout the year. These conditions remain unchanged in spite of the fact that the majority of amphibians in the Indonesian Archipelago have migrated there from northern areas where they are known to undergo seasonal physiological and reproductive cycles as do other temperate-zone amphibians.

It has recently been shown by Church (*1*) and his co-workers (*2*) that in *Bufo melanostictus* and *Rana cancrivora* the reproductive patterns and underlying physiological mechanisms governing them, as indicated in the storage of liver glycogen, fat bodies, hemoglobin concentrations, and pituitary sizes and secretions, have been altered from the temperate-zone norms to favor a more

complete adaptability of the animals to the unchanging tropical environment into which they have migrated.

From these studies it was found that not only the reproductive physiology, but also the growth of the animals, was affected directly or indirectly by the unchanging climate.

It is a well-known fact that a poikilothermous animal will continue to grow throughout its lifetime, and size thereby becomes a measure of age. It is usually assumed that this growth and accretion of bulk is attained for the most part through the mitotic increase of cells, although Donaldson (*3*) has shown that in the cerebral cortex of the rat the number of cells increases until about 20 days after birth, after which the subsequent increase in the weight of the brain is due largely to increase in the size of the cells; and Ott (*4*) reported that rat muscle increases in size in much the same way. A comparable auxesis has been found to occur in *Bufo melanostictus*.

In a study of the blood of *B. melanostictus*, erythrocytes have been found to increase in size continuously throughout the life of the animal. The sizes of the cells were determined by planimetric measurements of camera lucida drawings of blood smears taken from animals varying in size from tadpoles showing hind-limb buds just beginning to develop, through metamorphosis, to the largest adults available (snout-vent length approximately 90 mm). In all, the blood of 16 groups, representing 160 animals, was examined. Ten cells of each of ten animals in each group, totaling 100 cells per group, were drawn and measured.

When the mean size of the erythrocytes was plotted against the mean snout-vent lengths of the animals in a group from which the blood was taken, the size of the erythrocytes was found to increase with the size of the animal, those of the largest adults attaining a size twice that of a small tadpole (Fig. 1). Wintrobe (*5*) has reported varying erythrocyte size in different amphibian species, and Fankhauser (*6*) has shown variations in cell size to occur in heteroploid salamanders. But, except for a decided decrease in size when the animals left the water after metamorphosis, these results show a continuous increase of erythrocyte size with age in normal specimens within the same species (Fig. 2).

Work in progress indicates that perhaps all somatic cells in *B. melanostictus* continue to grow auxetically throughout life, and one of the interesting aspects of the investigation is that not only the morphology of the animals is involved but also their physiology.

Preliminary studies indicate that kidney cuboidal epithelial cells and intestinal columnar epithelial cells continue to increase in size as the animals grow larger. The same may also prove true for liver cells.

Physiologically, in spite of the fact that the erythrocyte count in *B. melanostictus* remains more or less constant regardless of size, the hemoglobin concentration, packed cell volume, and the specific gravity of the whole blood also increase with the size of the animals

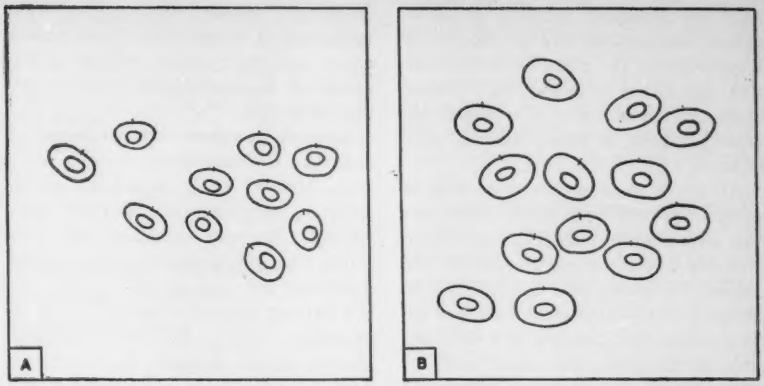

Fig. 1. Camera lucida drawings showing size differences between (*A*) the erythrocytes of a *Bufo melanostictus* tadpole with limb buds just beginning to appear and (*B*) the erythrocytes of a large adult with a snout-vent length of 90 mm (about × 210).

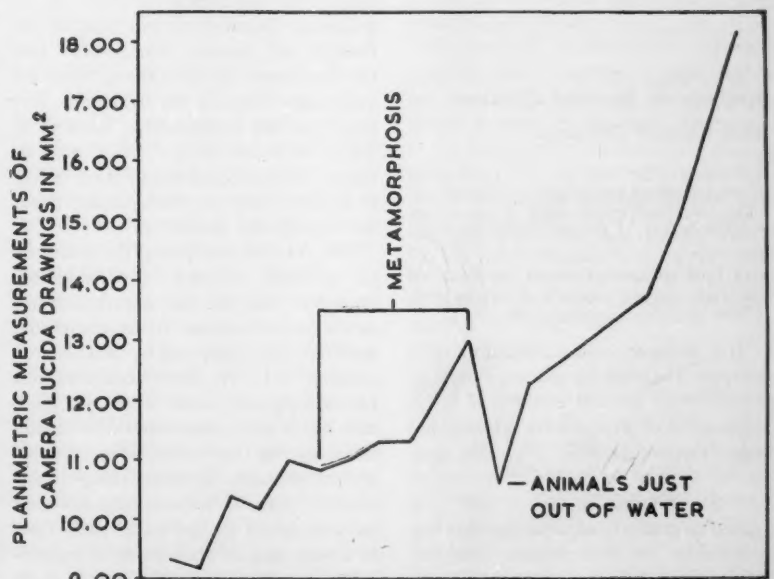

Fig. 2. Auxetic growth of the erythrocytes of *Bufo melanostictus*. *A* to *K* represent stages in tadpole development; 10 to 90 mm are the snout-vent lengths of metamorphosed animals. Tail resorption began at stage *F* and metamorphosis was completed at stage *K*. The animals had a snout-vent length of 10 mm when they left the water. Except for a decrease in the size of erythrocytes when the animals left the water, which was perhaps due to dehydration, the erythrocytes continued to increase in size until in the largest adults they were almost twice as large as in the smallest tadpoles.

(*7*). In females, the picture is complicated by a further increase in hemoglobin concentration and specific gravity accompanying the maturity of the ovarian eggs. In the same way, the glycogen concentration of the liver is higher per gram of tissue in larger animals than in small (*8*).

All in all these results show that as auxetic growth continues, concomitant physiological changes occur which probably affect the metabolism of the animal. To clarify this conclusion, the effects of environmental changes in temperature, dehydration, and diet, and possible changes in the serum proteins, are being investigated in addition to the studies mentioned above.

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27 January 1961

Synthesis of Bacterial Cellulose from Labeled Precursor

Abstract. The isolation and purification of an immediate precursor of bacterial cellulose was confirmed with glucose randomly labeled with carbon-14. The glucose appears to be bound within the cell to a lipid, is carried across the bacterial cell wall, and is incorporated enzymatically into cellulose extracellularly.

The isolation and purification of a compound containing glucose bound to a lipid, from ethanol extracts of active suspensions of *Acetobacter xylinum*, has been described recently (*1*). This compound appears to be the precursor of bacterial cellulose in that it will form typical microfibrils in aqueous solutions containing an extracellular enzyme. Preparations of the compound were shown to be homogeneous by two-dimensional chromatography in an acidic and a basic solvent, as tested by four detector systems, including autoradiography. We report here confirmation of the previous work from the results of a study of the transfer of glucose randomly labeled with C^{14} from the above compound to cellulose, under conditions which simulate in vivo formation of microfibrils. These results afford additional insight into the mechanism of biosynthesis of cellulose by this bacterium.

Labeled precursor was prepared as follows: Cellulose-free, washed cells from 100 ml of a suspension of *A. xylinum*, prepared as described previously (*2*), were incubated for 4 or 5 min (depending on the activity of the individual cell suspension) at 35°C in a 2 percent glucose solution, 0.01*M* in phosphate buffer, *p*H 6.0. Sufficient glucose in this solution was randomly labeled with C^{14} to give radioactivity of 2.5 μc/ml of initial solution. The isolation of the precursor from ethanol extracts of these suspensions, in the fourth fraction off a magnesium trisilicate-Celite column, M4, was carried out as reported earlier (*1*). For autoradiography of the labeled preparations, paper chromatograms (acid-washed Whatman No. 1 paper 7 by 7 in.) were developed two-dimensionally by the descending technique in *n*-butanol, acetic acid, and water (4:1:1) and *n*-butanol, pyridine, and water (10:3:3). The chromatograms were then placed in contact with medical x-ray film, which was developed after 4 days of exposure. Quantitative estimates of the fraction of glucose incorporated into the precursor at any instant were not undertaken because the fraction is very small and the compound is sensitive to traces of water on the paper. For instance, drying the preparation on initially slightly damp chromatographic paper will completely destroy it.

The fraction containing the precursor of bacterial cellulose, M4, exhibited only one spot on the autoradiograms in the same position as the compound detected previously (*1*) by KIO_4-starch reagent (*3*). At low concentrations round compact spots were observed, but at higher concentrations severe streaking of the chromatogram was always present. This streaking is attributed both to a slow breakdown of the compound in the water phase and to a slow rate of attainment of equilibrium. No traces of the predominant compounds in the suspension medium, glucose, and the gluconates were detectable in the autoradiograms of the M4 fraction.

The incorporation of a component of M4 fraction into bacterial cellulose, under certain conditions, was demonstrated as follows: (i) 1 ml of M4 incubated with 1 ml of water for 30 min at 35°C; (ii) 1 ml of M4 incubated as above with 1 ml of an ultrafiltered supernatant fraction of an active culture which contains an enzyme catalyzing cellulose formation (*4*); (iii) 1 ml of ultrafiltered supernatant fraction incubated alone for 30 min at 35°C. After incubation, each sample was diluted to 10 ml with redistilled absolute ethanol and centrifuged at 15,000 *g* for 15 min. The pellet, if any, was re-extracted with 3 ml of chloroform to remove lipids and recentrifuged.

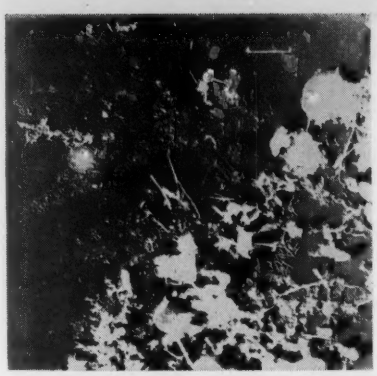

Fig. 1. Typical chloroform-ethanol insoluble, alkali-resistant, amorphous material formed by M4 fraction in the presence of only water.

Ethanol-chloroform insoluble material was formed principally in (ii), very little in (i), and none in (iii). The pellets from (i) and (ii) were digested with hot 4 percent NaOH to remove noncellulosic polymers (*4*), washed free of NaOH, dispersed in water,

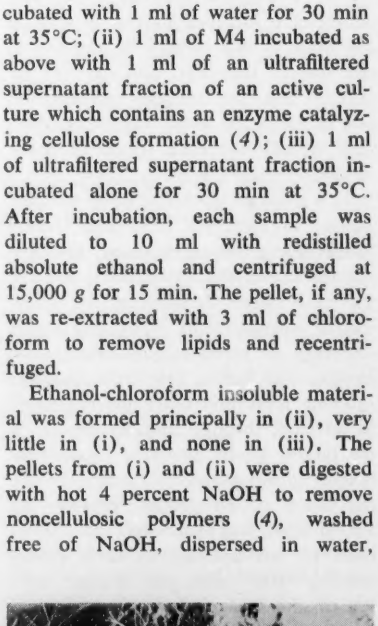

Fig. 2. Typical chloroform-ethanol insoluble, alkali-resistant cellulose microfibrils formed by the M4 fraction in the presence of an enzyme in the ultrafiltered supernatant fraction of an active culture of *A. xylinum*. Note the presence of substantial amorphous material also.

dialyzed, mounted, and shadowed for examination in the electron microscope. Most of the material from (i) dissolved in hot NaOH and showed only traces of amorphous substance (Fig. 1). Conversely, material from (ii) was fibrillar, resembling normal bacterial cellulose microfibrils (Fig. 2), and gave a positive anthrone reaction (*5*). Radioactivity was detected when the microfibrillar material was spread on a planchet under a counter and when it was exposed as a thin film to an x-ray emulsion. The combined ethanol and chloroform extract from (i) was radioactive, but no radioactivity was detectable in the combined extracts from (ii).

These results confirm the previous conclusion that the compound in the M4 fraction is an immediate precursor of bacterial cellulose. They also confirm the conclusion that a catalyst, which is probably an enzyme, is required for the formation of the cellulose microfibrils from the precursor, and that this enzyme is present in the extracellular medium of *A. xylinum*. This conclusion has been substantiated recently for *A. acetigenum* also (*6*). In the presence of the enzyme, the glucose is transferred mainly from soluble precursor into insoluble cellulose microfibrils by tip growth (*7*). No evidence for the necessity of a primer was observed, but these experiments do not exclude this possibility. These results thus support the postulation of a diffusible intermediate by Schramm *et al.* (*8*).

Presumably the precursor, containing lipid-bound glucose, is formed within the cells from glucose taken up during incubation. The bound activated glucose is then transported across the cell wall, perhaps aided by the presence of a substantial lipid moiety. After the extracellular enzymatic transfer of the glucose portion of the molecule to the growing microfibril, the lipid fraction is probably recycled since it does not accumulate in the medium (*9*).

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* National Research Council postdoctoral fellow, 1958–60.

20 February 1961

Nondestructive Method for Estimating Chlorophyll Content of Leaves

Abstract. A quantitative relationship is shown to exist between the chlorophyll content of soybean and Valencia orange leaves and their percentage reflectance of light of wavelength 625 mμ as measured by a colorimeter with reflectance attachment.

Incident to an investigation of the response of plants to iron supply, a method was needed whereby successive daily estimates of chlorophyll content could be made on the same leaf. Standard methods were not suitable because they require destruction of the leaf. Since chlorotic leaves become greener to the eye as the chlorophyll content increases, it seemed likely that reflectance of certain wavelengths from a leaf surface might be sufficiently well correlated with the chlorophyll content to serve as an estimate of that content. Reflectance measurements of leaves have been reported (*1*), and a general relationship has been recognized between the percentage of incident light reflected and the chlorophyll and carotenoid pigment concentrations (*2*). Apparently no attempt has been made to utilize this relationship to obtain quantitative indications of changes occurring in the chlorophyll content of leaves.

The basic instrument used was a colorimeter (Bausch and Lomb Spectronic 20) equipped with a reflectance attachment. It was soon established that the least difference in reflectance from the under surfaces of green and chlorotic soybean leaves occurred at wavelengths of about 665 and 465 mμ, while the greatest difference occurred at a wavelength of about 570 mμ. These wavelengths occur in the regions of maximum and minimum absorption of chlorophyll and agree with the results cited by Gabrielsen (*2*). Since the greatest difference in reflectance occurred at 570 mμ, this wavelength seemed to be the one to employ in developing a relationship between chlorophyll content and reflectance. It was found, however, that a still greater spread in reflectance from green and chlorotic leaves could be obtained by using a wavelength of 625 mμ and placing a filter with peak transmission at that wavelength between the leaf and the white magnesium carbonate reflecting surface.

To establish quantitative relationships between reflectance percentage and chlorophyll content, reflectance was measured for several hundred soybean leaves exhibiting different degrees of chlorosis induced by iron deficiency. These leaves were then sorted into groups. All leaves with reflectance readings between 33 and 37 percent (average 35) were placed in one group, those between 38 and 42 percent in the next group, and so on. Replicate determinations were made of the chlorophyll content of each group, by the spectrophotometric method described by the Association of Official Agricultural Chemists (*3*). The coefficient of variability of chlorophyll content within a group was found to be 8 percent. The results of these determinations (Fig. 1) show a high inverse relationship between the logarithm of the reflectance percentage and the chlorophyll content of the leaves within the range of concentrations studied.

To test the method on a different type of leaf, Valencia orange leaves were used. These leaves, exhibiting different degrees of chlorosis, regardless of the cause, were collected at random from local trees. The relationship between reflectance readings and chlorophyll content was found to hold about as well for these leaves (see Fig. 1) as for soybean leaves, except at the higher levels where the straight-line relationship no longer held.

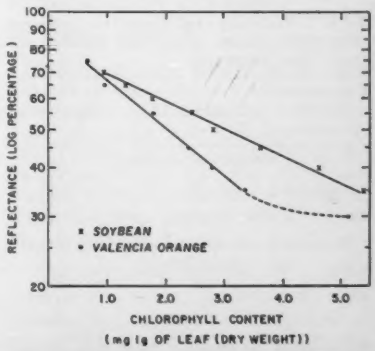

Fig. 1. Relationship between reflectance and chlorophyll content of leaves.

The close correlation between reflectance readings and chlorophyll content indicates that changes in reflectance from day to day may be used to estimate changes in the chlorophyll content of a leaf from day to day. This is especially true for chlorotic leaves; for greener leaves, when the chlorophyll content approaches the maximum, further increases may not be proportionally indicated by decreases in reflectance. Because of this and other limitations, the method can be used to the greatest advantage in detecting changes or relative differences in the chlorophyll content of leaves responding to different treatments.

Reflectance readings for a given chlorophyll content have been found to change with the age of the vacuum tubes and batteries of the instrument as well as with the species and variety of the plants being studied. The instrument should therefore be calibrated regularly against standard chlorophyll determinations.

Other precautions must also be taken. The readings must be made in the shade and not in direct light, and care must be taken that a major vein does not intercept the light beam to be reflected. Light must be prevented from leaking into the instrument around the edges of the leaf. A small cushion of black foam rubber around the opening for the light source is helpful for this purpose. Readings must be made consistently from the same surface and the same portion of the leaf. When checkered or mosaic types of chlorosis develop, such as in manganese deficiency, it may be necessary to calculate the mean of many readings on the same leaf.

The results shown in Table 1 indicate how the method has proved useful in indicating the rate of chlorophyll development in leaves receiving iron in different forms. One hundred such readings can easily be made in 1 day (*4*).

Table 1. Percentage reflectance and estimated chlorophyll content of soybean leaves in different iron treatments.

Days from start of treatment	Treatment 1*	Treatment 2†
	Percentage reflectance	
0	56	58
5	41	50
8	35	45
	Estimated chlorophyll content, dry weight basis (mg/g)	
0	2.3	2.1
5	4.4	3.0
8	5.3	3.8

* Iron added to Hoagland solution as 0.5 part of iron nitrilotriacetate per million. † Iron added to Hoagland solution as 0.5 part of iron ethylene bis-hydroxyphenylglycine per million.

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16 February 1961

Action of Gamma-Irradiation on Dimethyl Uracil in Aqueous Solution in Absence of Oxygen

Abstract. The action of ionizing radiations on dimethyl uracil in aqueous solution, in the absence of oxygen, was found to lead to the formation of the 4-dihydro, 5-hydroxy dimethyl uracil (I), shown to be identical with that formed by the action of ultraviolet radiation. In addition, the corresponding 4,5-glycol (II) has also been identified as one of the reaction products.

It has been shown by Sinsheimer and Hastings (*1*) that the action of ultraviolet light on uracil in aqueous systems leads to a well-defined photoproduct, which was suggested to be 4-dihydro, 5-hydroxy uracil. This supposition was later confirmed by the synthesis of such compounds by various authors; in particular the dihydro-hydroxy compound from dimethyl uracil could be obtained in a crystalline form (*2*).

We have recently studied the action of ionizing radiation (Co^{60} γ-rays and 200-kv x-rays on aqueous solutions of uracil and dimethyl uracil. In the presence of oxygen, the pyrimidine bases give the more or less stable hydroxy-hydroperoxides and also the corresponding glycols (*3*). The radiation-induced formation of a glycol from cytosine has recently been reported by Eckert and Monier (*4*).

In solutions irradiated in the *absence* of oxygen, we have now been able to identify among the products the corresponding pyrimidine 4,5 glycol and, in the case of dimethyl uracil, the 4-dihydro, 5-hydroxy compound (Fig. 1). The mechanism of the formation of the dihydro-hydroxy compound and of the glycol could go by way of the successive addition of a hydrogen atom and of a hydroxyl radical or of two hydroxyl radicals at the 4 and 5 double bond or by dismutation between two pyrimidine radicals. It is, however, also possible that in this system the formation of the dihydro-hydroxy compound proceeds in a way somewhat similar to the photochemical process—that is, by excitation of the pyrimidine molecule—since it has been pointed out previously that the relatively low energy electrons, formed in the absorption of ionizing radiations, should be able to bring about excitation processes similar to those produced by ultraviolet radiation (*5*).

Dimethyl uracil, in particular, was chosen as a model compound as it had been previously investigated in detail.

In the presence of oxygen a product is formed which on treatment with acid gives an ultraviolet-absorbing compound having a peak at 283 mμ at *p*H 2 and at 310 mμ at *p*H13. This latter product was identified by chromatography as dimethyl isobarbituric acid, suggesting that the original radiation product was dimethyl uracil glycol (II).

In the absence of oxygen, irradiation gave rise to a product, which on treatment with acid also gave an increase in the ultraviolet absorption with an absorption peak at 269 mμ at *p*H 2; on subsequent treatment with alkali (to *p*H 13) this spectrum was modified to give two peaks, a major absorption at

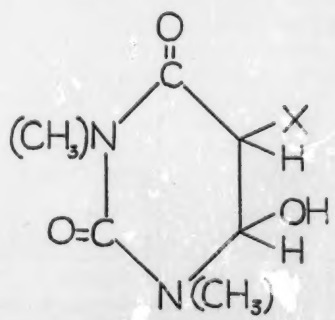

Fig. 1. Structure of the 4-dihydro, 5-hydroxy dimethyl uracil (I) and the corresponding 4,5 glycol (II). In I, *X* is H; in II, *X* is OH.

266 mμ and a smaller peak at about 310 mμ. This spectral behavior can be accounted for if the formation of both the glycol and the 4-dihydro, 5-hydroxy compound (I) are assumed to occur in the ratio of about 1:3. The glycol gives, on acid treatment, dimethyl isobarbituric acid and the dihydro-hydroxy compound, after the acid-catalyzed dehydration, gives dimethyl uracil with an absorption maximum at 266 mμ in both acid and alkali solutions.

The dihydro-hydroxy product and the glycol have also been characterized in other ways.

1) Chromatography of the product treated with acid showed the presence of both dimethyl isobarbituric acid and dimethyl uracil.

2) The rate of formation of the ultraviolet-absorbing product on treatment with acid was compared with the rate of formation of the ultraviolet-absorbing product formed photochemically from dimethyl uracil.

The second order rate constant (at 25°C) of the acid-catalyzed restoration of the ultraviolet absorption at *p*H 1.30 was found to be 1.13×10^{-2} lit. mole^{-1} sec^{-1} for the photochemical product and 1.10×10^{-2} lit. mole^{-1} sec^{-1} for the product obtained on irradiation with x-rays; this latter value was confirmed by measurements of the rate of double-bond restoration from the uptake of molecular bromine, which gave a rate constant of 1.12×10^{-2} lit. mole^{-1} sec^{-1}.

These figures support the conclusion that one of the products formed by x-irradiation of aqueous solution of dimethyl uracil, in the absence of oxygen, is the 4-dihydro, 5-hydroxy compound, identical with that produced photochemically (*6*).

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9 January 1961

Five New Minerals from Moctezuma, Sonora, Mexico

Abstract. Five new minerals have been found in a tellurium deposit near the town of Moctezuma, Sonora, Mexico. Preliminary study shows that they are a lead-oxy-fluoride, a zinc tellurite or tellurate, a manganese-zinc tellurite or tellurate, a manganese tellurite or tellurate, and an iron tellurite or tellurate.

Mineralogical interest in the deposit at Moctezuma was first aroused by the identification of several rare minerals, including mackayite, emmonsite, tellurite, native tellurium, and paratellurite. Paratellurite was recently described by Switzer and Swanson (*1*). Moctezuma is the second occurrence of mackayite and paratellurite.

Five new species of minerals have been found in this deposit. Since complete chemical data are not available, the naming of these minerals is being delayed. Preliminary descriptions of the five minerals follow.

Lead-oxy-fluoride, which was found in extremely small amounts, occurs as minute, yellow plates with a high adamantine luster. The x-ray powder data agree with those for synthetic Pb_2OF_2 published by Byström (*2*). The x-ray data and appearance of material synthesized during the present study are the same as those of the natural mineral. At present, there is not enough of the mineral for a chemical analysis.

Zinc tellurite or tellurate occurs as small, brown, hexagonal prismatic crystals terminated by a bipyramid. It is optically uniaxial positive with $\omega = 1.85 \pm 0.01$ and $\epsilon = 1.93 \pm 0.01$. A spectographic analysis gave only zinc and tellurium as major constituents. The x-ray powder data do not match those of any known tellurium minerals. The strongest spacings (in angstroms) are 8.1 (very strong), 4.04 (strong), and 2.75 (strong).

Manganese-zinc tellurite or tellurate is a red to purple mineral which occurs in platy masses. Partial optical data are: biaxial positive, $2V = 60°$ (estimated, $\beta = 1.89$, and $\gamma > 2.10$. The specific gravity, determined with the Berman balance on 20 mg of material, is 5.01 ± 0.02. Since only manganese, zinc, and tellurium were reported as major constituents by spectrographic analysis, the mineral is probably a manganese-zinc tellurite or tellurate. X-ray powder data are different from those of known tellurium minerals. The strongest spacings (in angstroms) are 2.98 (very strong), 3.30 (strong), 1.62 (strong), 4.00 (strong −), 4.93 (medium strong), and 2.21 (medium strong).

Manganese tellurite or tellurate occurs as pale green to colorless platy masses and occasionally as small euhedral crystals. The crystals are plates and have an octagonal shape. The material examined has variable physical properties, and an isomorphous series is indicated. The following data are averages of values obtained from several samples. The mineral is optically biaxial positive, $2V = 15°$ (estimated), α and β are approximately 1.89, and γ is about 2.0. The specific gravity is 5.05. Spectographic analysis yielded manganese and tellurium as major constituents and zinc in lesser amount. Strongest spacings (in angstroms) are 2.03 (strong), 3.36 (strong −), and 2.61 (strong −).

Iron tellurite or tellurate (a mineral or mineraloid) is amorphous to x-rays and occurs as red-brown botryoidal coatings. Optically the material is very weakly anisotropic and has a mean index of 1.885 ± 0.005. The specific gravity is about 3.7. Only iron and tellurium were detected as major constituents by spectographic analysis.

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7 February 1961

Evaluation of the Origins of Strontium-90 Contained in Wheat Plant

Abstract. Twenty percent of the strontium-90 in wheat flour in 1959 was due to root absorption, 30 percent was due to floral absorption from soil particles attached to the ear, and 50 percent was due to current fallout. In 1960, 35 percent was due to root absorption, 50 percent to floral absorption from soil, and 15 percent to current fallout.

For evaluation of the Sr^{90} hazard level in the future, the argument concerning radioactive contamination of wheat and other cereals by fallout has been narrowed down to the problem of how much Sr^{90} in grain depends on the

Table 1. Strontium-90 concentration (strontium unit, micromicrocurie of Sr^{90} per gram of Ca) in various parts of wheat plants harvested in 1959 and 1960. Treatment I is the sample with the ear covered with a paraffin-paper envelope during the period from ear-shooting to harvest. Treatment II is the sample with the whole plant covered with a polyethylene sheet during the same period.

1959	1960	1960	
		Treatment I	Treatment II
		Leaf	
650	180	180	92
		Husk	
1800	690	190	82
		Bran	
340	80	30	37
		Flour	
160	95	38	25

cumulative Sr^{90} deposition in soil and how much depends on the current Sr^{90} fallout rate (*1*).

The wheat plants harvested in 1959 and 1960 at Chiba City were analyzed for Sr^{90} content. In addition, special treatments were applied to the 1960 samples. One group from this year was covered with a polyethylene sheet on the whole body from the shooting stage until harvest; another group was covered, during the same period, with a paraffin paper envelope on the ear only to eliminate the floral absorption of Sr^{90}.

The concentrations of Sr^{90} in various parts of wheat were found to be much lower in 1960 than in 1959. This should be caused by the marked decrease of the Sr^{90} fallout rate in the spring of 1960 compared with that during the corresponding period in 1959. But the difference in the Sr^{90} content in wheat during these years is so small compared with the remarkable difference in the Sr^{90} fallout rate in the spring of these two years. The monthly fallout rate of Sr^{90} from April to June in 1959 was approximately 1 to 2 mc/km^2; for the same period in 1960 it was 0.2 to 0.3 mc/km^2 (*2*). This period is from ear-shooting to harvest of the wheat plant. Direct Sr^{90} contamination of grain by current fallout would be mostly from fallout during this period, because not much radioactive strontium, which has accumulated in the foliage, can be transmitted to the ear of the cereal plant (*3*).

From the above considerations, if the current fallout of Sr^{90} were the main contributor to the content of Sr^{90} in the grain, the content should be five times lower in 1960 than in 1959. But wheat flour showed a decrease of only one-half, or less, of the Sr^{90} content in 1960. These phenomena suggest that the cumulative deposit of Sr^{90} on land might have an important role in the amount in cereals. As for root absorption, the wheat-flour sample treated with the covering as stated already, which eliminated the floral absorption of Sr^{90}, showed about one-third of the amount in the untreated sample, as shown in Table 1. This value indicates the amount of Sr^{90} due only to root absorption from soil. Therefore, another fraction of Sr^{90}, namely two-thirds of the amount in flour in 1960, is due to floral absorption. But this is too large to be assumed to be due to current fallout of Sr^{90}, because the fallout rate of Sr^{90} in this period was only one-fifth of that in the corresponding period in 1959. Therefore, a pretty large fraction of this floral absorption might be due to the fine particles of surface soil raised up by the wind and adhering to the ear of the plants. The Sr^{90} in these particles might be absorbed directly into the grain. Thus Sr^{90} found in wheat flour could be separated into the following three categories, according to their absorptive routes: (i) floral absorption from current Sr^{90} fallout (x, 1960; $5x$, 1959); (ii) floral absorption from Sr^{90} in soil particles (y, 1959 and 1960); (iii) root absorption from cumulative Sr^{90} in soil (z, 1959 and 1960).

If the variables x, y, and z can represent the three fractions shown above, the following formulas can be obtained by using the values from Table 1.

$$5x + y + z = 160$$
$$x + y + z = 95$$
$$z = 30$$

On solving these formulas, the values of $x = 16$, $y = 55$, and $z = 30$ were obtained. With these values, obtained as above, the amount of Sr^{90} in wheat flour in 1959 and 1960 can be interpreted as shown in Table 2. As shown in the table, for the Sr^{90} content in wheat flour in 1959, when fallout of Sr^{90} was quite high in the spring, the current fallout rate contributed to one-half of the amount of Sr^{90}. On the contrary, in 1960, when the fallout rate was much lower, the current fallout rate contributed to only one-sixth or one-seventh of the amount. The floral absorption from the soil particles raised up by the wind was the largest contributor.

Table 2. Evaluation of each fraction of Sr^{90} in wheat flour due to various origins of contamination. Amounts are in strontium units. Numbers in parentheses indicate percentages.

Origin	1959	1960
From soil		
Root absorption	30 (20)	30 (35)
Floral absorption	50 (30)	50 (50)
From current fallout		
Floral absorption	80 (50)	15 (15)

For bran, husk, and leaf, the contribution of the current fallout rate is assumed to be larger than for wheat flour, as seen in Table 1.

From these considerations, the Sr^{90} content of wheat flour is assumed to maintain the level of the 1960 sample, unless the Sr^{90} content in soil should change for any reasons, such as leaching out, decrease of availability for plant, and so forth, because the present level of Sr^{90} in wheat flour is mostly (approximately 80 to 90 percent) originating from soil contamination (*4*).

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MICHIKO ABE
MASAKO ETO

National Institute of Radiological Sciences, Chiba City, Japan

References and Notes

1. R. S. Russell, "The contamination of vegetation," FAO Committee on Radioactive Materials in Food and Agriculture, Session 7(b), A.R.C. 687/59 (1959).
2. M. Izawa *et al.*, unpublished data; Y. Miyake *et al.*, unpublished data.
3. L. J. Middleton, *Nature* **181**, 1300 (1958).
4. We are grateful to Messrs. Suzuki, Miwa, and Igarashi, research officials of Chiba Agricultural Research Station, for the kind help and facilities they provided.

12 December 1960

Science Teaching in Elementary and Junior High Schools

A study made by the AAAS, with the aid of a grant from the National Science Foundation, is reviewed by the steering committee.

"It is not at all necessary that the average man should be acquainted with the latest theory of the universe or the newest hormone, but it is very necessary that he should understand as clearly as possible the purpose and methods of science. This is the business of our schools, not simply of the colleges but of all the schools from the kindergarten up."—GEORGE SARTON

There is urgent need for major improvement in the science instruction offered in elementary and junior high schools. In the hope of finding ways to effect this improvement, three conferences of teachers and scientists, all sponsored by the AAAS but conducted independently, recently considered the following aspects of science instruction: present practices and materials; recent efforts to create new courses for senior high schools; and recent experiments in teaching young children.

The conferences reached the following conclusions: instruction in science should be a regular part of the curriculum from kindergarten through grade 9 (and beyond, but the conferences considered only these grades); a major effort to improve science instruction in these grades should be undertaken; and this effort should involve improving both course materials and classroom teaching.

Conference Arrangements

In order to keep conference discussion groups to a manageable size and in order to include representatives of different parts of the country, three regional conferences were held instead of one large national conference. The conferences were held in St. Louis, Missouri, from 8 to 10 January 1961; in Berkeley, California, from 5 to 7 February; and in Washington, D.C., from 12 to 14 March. Each conference was arranged by a local committee, with Dean Thomas Hall of Washington University chairman of the St. Louis committee, Professor Owen Chamberlain of the University of California chairman of the Berkeley committee, and Professor John Toll of the University of Maryland chairman of the Washington committee.

Each conference included about 50 participants, drawn from the ranks of elementary and junior high school teachers, school principals, supervisors of elementary and junior high school science instruction, science educators, scientists from various disciplines, representatives of one or more of the senior high school course-content-improvement programs, and psychologists interested in learning and learning theory.

The local committee for each conference scheduled two or three addresses related to science education but left most of the conference time for discussion in small panels. At the final session of each conference the panel reports were presented and discussed by the entire conference.

Each panel was given a set of questions prepared by the local committee. The questions varied from one conference to another. Each conference worked without knowledge of the recommendations of any previous conference. Participants in all three conferences were furnished background information concerning the current status of science teaching in the elementary and junior high school grades and the texts available for these grades. The background papers (*1*) were "Science for grades seven, eight, and nine," by Abe S. Fischler; "The current status of science education in the elementary schools," by Jacqueline V. Mallinson; "Current activities in elementary and junior high school science," by Dorothy C. Matala; "Elementary school science and mathematics education in Western Europe," by Margaret J. McKibben; and "Review of science textbooks currently used in elementary schools," by Albert Piltz.

The independence of the three conferences and the somewhat different questions that were posed to start the discussion groups to work should be emphasized, for out of this diversity came clear agreement upon a number of statements and recommendations.

Points of Agreement

There was very substantial agreement upon all of the following points.

1) *Science should be a basic part of general education for all students at the elementary and junior high school levels.* As a part of general education, science should constitute a regularly scheduled part of the curriculum in all grades. The purpose is to equip all persons for life in a scientific and technological society. If all of the more than 35 million pupils in elementary and junior high schools can be given good experiences in science, all will have a good start toward scientific literacy. Young children are naturally curious about the universe and are continuously exploring their immediate environment. During these early years children form their basic attitudes, patterns of thinking, and modes of behavior. It is therefore during these years that particular attention must be given to establishing the attitudes and modes of inquiry that are associated with the scientific enterprise—its processes and content. Whatever the school does, children are inevitably exposed to "science" and technology through all forms of mass communication, but they can acquire understanding of these powerful forces only

Members of the steering committee for the study are Thomas S. Hall, Washington University, chairman; Paul E. Blackwood, U.S. Office of Education; Margaret W. Efraemson, Rudolph S. Walton Public School, Philadelphia; Philip G. Johnson, Cornell University; John R. Mayor, AAAS; Thornton Page, Wesleyan University; and Dael Wolfle, AAAS.

through an orderly intellectual experience in the study of science. This orderly intellectual experience is the responsibility of the school.

2) *Instruction at the elementary levels should deal in an organized way with science as a whole.* Science instruction should not be limited to one of the separate disciplines, such as biology, chemistry, or physics, but should develop specific awareness of natural phenomena, good habits of observation, understanding of classification, function, quantification, order, and other basic ideas used in science, drawing on all the sciences for examples. Certain areas serve best to illustrate or instruct in certain aspects of scientific reasoning, and the significance of scientific principles can best be made apparent when they are shown to be applicable in several fields. Although flexibility and variety are desirable, it is essential to have a well-defined structure for science courses, so that the load of answering extraneous questions does not become impossible for the elementary teacher, and so that the order and connectivity of science can be properly presented.

3) *There must be a clear progression in the study of science from grade to grade.* Science instruction at the elementary and junior high school levels should be planned and coordinated as a ten-year sequence, beginning with kindergarten and continuing through grade 9. (Science should continue to be a part of the curriculum in grade 10 and beyond, but this report covers only the kindergarten-to-grade-9 period.) Haphazard samplings, uncoordinated repetitions, overlap and glaring omissions should yield to systematic developmental instruction in science, based on the best knowledge of science itself, the scientific needs of society, the maturing child, and the learning process. While one purpose of a planned progression is to avoid boring and wasteful repetition of the purely descriptive treatment of such subjects as the solar system, weather, and the classification of leaves, a more important purpose is to introduce as early as possible the methods and systematic characteristics of scientific inquiry.

4) *There should be no single, national curriculum in science.* The conference participants were insistent that no attempt be made to develop a single program for use in all school systems. This judgment was based partly on philosophical objections to central dictation of curricular planning, and partly on recognition that alternative choices of subject matter and order of progression might be equally effective. In different regions of the country different illustrative materials are available. The pace and level of instruction differ from one school to another. So do the details of the curricular organization into which science instruction must be made to fit. Schools will therefore wish to have some choice among well-designed sets of science materials. Moreover, no one knows the best order and selection from among all that might be taught; alternative sets of material should be tried out.

5) *Science teaching should stress the spirit of discovery characteristic of science itself.* Nothing is more contrary to the spirit of science, and nothing more damaging to student and teacher morale, than to present science as a series of factual findings to be memorized. The science curriculum will, of course, teach concepts, theories, principles, and content areas, but the real purposes behind their selection must be kept in mind, and while the student is learning content he should also be learning methods of observation, the importance of checking observations, the role of measurement and the use of instruments to extend man's senses, how to interpret and be critical of data, and that as a quest for new knowledge science is constantly changing. These purposes are not achieved if students simply memorize findings without "discovering" them, or recognizing how they were discovered. Discovery is possible at all levels. The simplest step for the child is to discover phenomena and to observe relationships that are new to him; at a higher level he can learn to discover relationships by experimentation; and at a still higher level he should learn to discover by abstract reasoning.

6) *New instructional materials must be prepared for in-service and pre-service programs for science teachers.* In addition to the instructional materials to be used by the pupils, it will be necessary to prepare a comprehensive set of instructional aids to be used by the teachers and by those who provide instruction for teachers—a clear rationale of the science program, manuals and guides to provide ideas for various types of activities, monographs for basic information and for supplementary study, descriptions of suitable demonstrations and displays, instructions for appropriate experiments, and films and other audio-visual aids. Sample tests and examinations should also be provided as a basis for proper evaluation of student progress, and as guides to the teachers in preparing examinations that will emphasize scientific principles and methodology instead of the memorization of facts.

7) *The preparation of instructional materials will require the combined efforts of scientists, classroom teachers, and specialists in learning and teacher preparation.* A substantial team effort will be required to produce the high-quality materials needed for a major improvement in science teaching. This high quality can best be assured if scientists, classroom teachers, science supervisors, college staff members who offer science courses for teachers, psychologists and experts in child development, and specialists concerned with reading and other instructional aids work closely together in the production and in the revision of materials.

8) *There is great urgency to get started on the preparation of improved instructional materials for science.* Each year of delay means that one additional age group of children will finish school without the advantage of the kind of excellent science instruction that could be provided. We lack sufficient knowledge of child development and of how children learn science to assure production of the best possible teaching materials, but improvement based on the knowledge that is available should be started now, while investigations or research go forward to lay the basis for still better teaching materials in the future.

Discussion of the Curriculum

The present concern regarding science education in the elementary and junior high schools derives from the feeling that future citizens must be generally cognizant of the nature of science and its role in human existence.

This basic point and those stated earlier were expressed by all three conferences. A number of additional recommendations for improving science instruction and a number of specific suggestions were made in the reports of one or more of the discussion panels of the three conferences. The reports of the individual discussion groups have been distributed to the participants and

will be made available to those who may be assigned responsibility for the proposed major effort. A sampling of these recommendations is given in this section.

The conference participants believe that science is an essential part of balanced educational development, and one panel recommended that the basic core of the elementary school curriculum be science and the humanities. Modern technology is an increasing part of common knowledge, but the study of science should not be subservient to the study of technology. More than anything else the purpose of science in general education is to develop a more complete view of life in a scientifically oriented world culture.

Such goals are not to be accomplished by an encyclopedic approach; appreciation of science can be developed only through understanding the qualities of scientific enterprise—the *process* of science. This process is an intellectual pursuit; to the extent that that it deals largely with concept formation and validation, it is a creative activity. Science education at all levels should be based on these major aspects.

The role of speculation, prediction, and test in science implies a quantitative as well as a qualitative approach. Thus, measurement and quantitative reasoning should play a role in the curriculum comparable to the observational and descriptive aspects of science. The participants felt that better coordination between science and mathematics is important, particularly in the junior high school, and that a definite effort should be made to make use of mathematical ideas and methods in science in grades 7, 8, and 9.

Several of the conference groups provided lists of examples of the science content for grades up through the ninth. Among broad concept areas listed in the several conference reports were cosmology, evolution, ecology, structure and function, reproduction and development, structure of matter, energy interrelations, and changes of state of matter. Two of the discussion panels proposed that in the junior high school one year each be devoted to topics from the earth sciences, the biological sciences, and the physical sciences.

In junior high school science the participants believe that it is much more desirable to study a limited number of topics in depth than to provide a sketchy introduction to a great many ideas. One group listed geometrical optics, electricity, mechanics, states of matter, structure of matter, use and control of energy, and environment and human needs (including earth, atmosphere, water resources, and biological resources). Any one of these areas was thought to deserve at least one fourth of the time in one of the junior high school years.

Other suggestions from various groups, on which there was general agreement, and which refer to science programs from kindergarten through junior high school, are as follows.

1) Strong blocks of knowledge should be developed which cut across traditional science disciplines. The sequence in which these units are used should be determined within a three-grade range by cooperative planning of the teachers concerned.

2) The curriculum should be flexible enough to provide satisfaction and enlightenment to all students and to challenge the academically talented.

3) Teachers should employ the experimental approach to science, with emphasis on inductive learning.

4) As he enters grade 10, the student should appreciate such philosophical aspects of science as the distinction between operational definitions and theoretical definitions, the relationship between speculation and observation, and the displacement of one theory by another.

Improvement of Teacher Education

One study panel at each conference was devoted to problems of teacher education. All agreed upon the great need for improvement in the science education of teachers at the elementary and junior high school levels. It is unrealistic to try to provide summer institutes for the nearly one million elementary school teachers who devote some of their time to science teaching. Hence institutes for this level of instruction may well be limited to elementary school personnel who can provide leadership for and assistance to other teachers.

The conferences gave a considerable amount of attention to administrative changes that would enable school systems to take greater advantage of teachers with special interest and training in science. One group recommended the use of specially competent science teachers to serve as consultants to classroom teachers in the elementary schools, in a ratio of one consultant to not more than 50 classroom teachers. This plan would require some 17,000 specialized teachers, employed by single school districts or groups of smaller adjacent districts.

The situation for junior high school teachers is of course very different. The numbers are not so large as to make it impossible to reach individual teachers. Some of the institutes for secondary school teachers are quite appropriate for junior high school teachers, and quite a number of the latter are already attending these institutes. Institute proposals based on new approaches to junior high school science may well be invited and supported.

The recommendations on institutes are intended as means of meeting an immediate need and also as continuing activities to supplement the teacher aids which may be prepared for the new courses. The great value of summer institutes for secondary school teachers, both as a means of strengthening their education in science and as a way of encouraging them to use the new course materials, is recognized in the strong and urgent recommendation that science institute programs for elementary and junior high school teachers be greatly strengthened and increased. The institute program should include the following.

1) Summer institutes and in-service institutes for elementary and junior high school principals, curriculum directors, science supervisors, special science teachers, and other teachers of known leadership qualities. An important criterion for attendance should be the potentiality of the individual as a leader in improving science programs in his own school system.

2) Institutes for junior high school science teachers under the regular secondary school institute program, but with special attention given to the problems of junior high school science.

3) In-service institutes for elementary or junior high school teachers within a school system or at a center serving several schools or school systems. Consulting scientists and consulting specialists in science education should be involved in the planning and teaching of these institute courses.

It is also urgent that college programs for prospective teachers be strengthened. These programs are likely to be modified when the new ma-

terials for elementary and junior high school instruction become available, but in the meantime, and more fundamentally, the following steps are proposed.

1) College science courses should be designed to give a fuller and wider spectrum of science. The courses would probably include materials drawn from several science departments and should teach the logical and operational assumptions on which science is built. The courses need not be specially designed for elementary teachers; those most appropriate for liberal arts majors and other nonscientists might be excellent for prospective teachers in the elementary grades. A working conference to clarify patterns may be useful.

2) Professional education experiences for prospective elementary teachers should include opportunity to observe the work of well-qualified teachers who like science and who like children. Prospective teachers should also be provided opportunities to gain experience in formulating questions that are meaningful to children, in developing methods for using quantitative approaches, in using audio-visual and laboratory materials, and in adapting to science instruction materials found in the surroundings of children.

3) All prospective elementary teachers should have an area of concentration. For some, this area should be science. The teachers who had concentrated in science could then become special science teachers or could assist other teachers less well acquainted with science.

Studies of Learning

Conference participants agreed upon the importance of encouraging additional studies of the learning process. The investigations proposed fall into two categories—those concerned with fundamental research in learning and those directly concerned with the selection and organization of content for science courses and with methods of teaching science.

It is not proposed that fundamental research in learning—research which could contribute to the improvement of teaching in all disciplines—become a part of the proposed national course-content-improvement program for elementary and junior high school science. The conferences and the steering committee, however, recognize the need for such research and strongly recommend that it receive more adequate support.

There are, however, problems for investigations that would directly support the development of improved elementary and junior high school science materials. Work on some of these problems should be planned as part of the recommended study. Examples are the kinds of instructional materials that are most effective in learning at different grade levels; the most effective use of textbooks, reading materials, laboratory equipment, films, television, and automated learning devices; development of better means of early identification of scientific and technical talent and appropriate instructional materials for talented pupils; study of readiness for the kinds of intellectual activities that are required in science learning and of the extent to which such readiness is a function of earlier experience; and development of better means for comparing the effectiveness of new teaching materials with that of other, more traditional ones.

Developing Course Materials

The program for the development of science materials for use in the elementary and junior high schools and of all of the supporting materials to be used by the teachers should be under the direction of a national advisory or steering committee. The steering committee should include scientists, science educators, teachers, supervisors, and learning specialists.

The following steps or stages, whether carried out at one or more centers simultaneously or successively, were agreed upon as necessary.

1) Identification of major scientific concepts, principles, and content areas to be covered and preparation of a sequential plan for their development.

2) Collation of present research data related to elementary and junior high school science instruction and definition of problems that need careful study.

3) Preparation of alternative blocks of material (texts, teachers manuals, tests, and so on) for the several grades or content areas.

4) Classroom trial, feedback of criticism and suggestions, and revision of the preliminary materials.

5) Preparation of sets of materials for general school use.

As a plan of action for accomplishing these goals we propose the establishment of several centers for the development of course materials. Each center should have its own working group of scientists, teachers, and other educational leaders and each its own set of cooperating schools trying out the new materials. The number of centers can be better determined after there has been more detailed consideration of all of the problems involved; we tentatively recommend that there be three. This number seems to offer a good compromise between the advantages of wide choice and the requirements of cost and other practical realities. While each center should have considerable autonomy to develop materials it considers best, the activities of all centers would be coordinated by the national steering committee, and all would have access to common supporting services—such as facilities for the development of films or equipment.

Administrative coordination and management of the centers for course and materials development might follow either of two patterns.

One possibility would be for the foundation that provides financial support to contract directly with the universities or other institutions that undertake to develop courses and materials. If this procedure is followed, the funding agency should establish a national steering committee that would work closely with the centers both in initial planning and throughout the developmental program. The steering committee could be established directly within the funding agency or through a separate contract.

The other and perhaps more desirable possibility would be for the supporting foundation to arrange with a single agency or organization to appoint the national steering committee and to establish the course materials development centers, either directly or through subcontracts with universities or other appropriate agencies.

Independent Studies

In recommending a massive and coordinated attack on the problem of improving science education, the study participants explicitly indicated that they do not wish to discourage or in-

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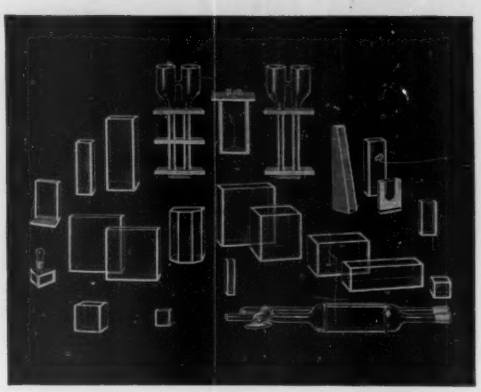

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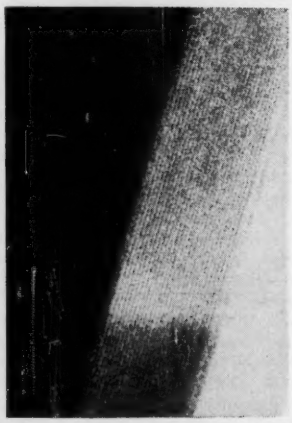

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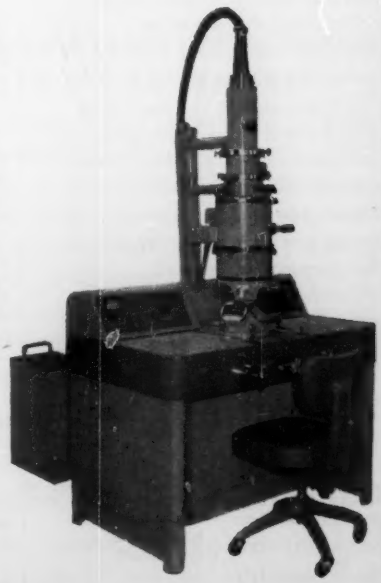

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terfere with other, independent efforts aimed at the same goal. While such independent studies are unlikely to attain the national attention that would be given to a more massive attack, they may well turn out to be more imaginative and bolder in conception and method of attack. Such independent studies should be encouraged, not discouraged, by the existence of a large and coordinated effort.

An Observation

A most encouraging aspect of the three conferences was the ease and satisfaction with which scientists, representing all of the major scientific disciplines, and educators, representing teacher education, administration, and the classroom, were able to reach agreement about needs for improvement of early science education and ways of bringing about that improvement. It was heartening to both scientists and educators to find such a high degree of agreement upon the importance and the feasibility of the task. The general spirit of the conferences was one of enthusiastic acceptance of joint responsibility and confidence that a large-scale, coordinated, and cooperative attack would produce major improvements in science education at the elementary and junior high school levels.

Reference

1. The background papers appear as articles by the authors in *School Science and Mathematics* (Apr., May, and June 1961).

Forthcoming Events

July

16–21. International Conf. on Medical Electronics, 4th, with Electrical Techniques in Medicine and Biology, 14th annual conf., New York, N.Y. (L. E. Flory, RCA Laboratories, Princeton, N.J.)

16–22. International Soc. for Clinical and Experimental Hypnosis, Rio de Janeiro, Brazil. (ISCEH, 33 E. 65 St., New York 21)

17–22. Soil Mechanics and Foundation Engineering, 5th intern. conf., Paris, France. (E. Caminade, Secretaire General, 23 rue de Cronstadt, Paris 15)

18–20. Pulmonary Structure and Function, Ciba Foundation Symp. (by invitation only), London, England. (Ciba Foundation, 41 Portland Pl., London, W.1)

18–21. Inorganic Polymers, intern. symp., Nottingham, England. (General Secretary, Chemical Soc., Burlington House, London, W.1, England)

21–22. World Power Conf. (members only), Moscow, U.S.S.R. (Central Office, 201-2 Grand Buildings, Trafalgar Sq., London, W.C.2, England)

23–28. Otolaryngology, 7th intern. congr., Paris, France. (H. Guillon, Secretary General, 6 Avenue Mac-Mahon, Paris 17)

24–28. Nematology Symp., 6th intern., Ghent, Belgium. (J. van den Brande, Soc. of European Nematologists, Rijksland-boushogeschool, Coupure links 235, Ghent)

24–29. Medical Electro-Radiological Societies, Latin Federation of, 5th congr., Paris, France. (C. Proux, Secretary, 9 rue Daru, Paris 8)

24–30. Urology, 12th intern. congr., Rio de Janeiro, Brazil. (J. Silva de Assis, Secretary, P.O. Box 1275, Belo-Horizonte, Brazil)

26. International Commission for the Prevention of Alcoholism, 7th annual meeting, Washington, D.C. (International Headquarters, 6840 Eastern Ave., NW, Washington 12)

26–28. Detection and Assay of Hormones by Immuno-Clinical Means, Ciba Foundation Colloquium (by invitation only), London, England. (Ciba Foundation, 41 Portland Pl., London, W.1)

27–1. Macromolecular Chemistry, intern. symp., Montreal, Canada. (Organizing Committee, P.O. Box 816, Sarnia, Ontario, Canada)

28–29. Linguistic Soc. of America, Austin, Tex. (A. A. Hill, Box 7790, University Station, Austin 12)

30–2. Soil Conservation Soc. of America, Lafayette, Ind. (H. W. Pritchard, 838 Fifth Ave., Des Moines 14, Iowa)

30–3. International Psycholanalytical Congr., 22nd, Edinburgh, Scotland. (Miss C. de Monehaux, 53 York Terrace, Regents Park, London, N.W.1, England)

31–4. Biophysics, 1st intern. congr., Stockholm, Sweden. (B. Lindström, Dept. of Medical Physics, Karolinska Institutet, Stockholm 60)

31–4. Differential Equations in Non-Linear Mechanics, Air Force Acad., Colorado Springs, Colo. (J. P. Lasalle, 7212 Bellona Ave., Baltimore 12, Md.)

31–11. Physics of the Solar System and Re-entry Dynamics, conf., Blacksburg, Va. (Bureau of Public Relations, Virginia Polytechnic Inst., Blacksburg)

31–12. Electric Power and Problems of Nuclear Power, seminar, U.N. Economic Commission for Latin America, Mexico, D.F. (A. Dorfman, Chief, Energy and Water Resource Program, Avenue Providencia 871, Santiago, Chile)

August

1–26. Functional Analysis, 8th American Mathematical Soc. summer institute, Stanford, Calif. (P. D. Lax, AMS, 190 Hope St., Providence 6, R.I.)

2–5. International Conf. of Pure and Applied Chemistry, 21st, Montreal, Canada. (R. Morf, Hoffmann-LaRoche, S.A., Grenzachterstrasse 124, Basel, Switzerland)

3–5. Canadian Chemical Conf. and Exhibition, 44th, Montreal. (Chemical Inst. of Canada, 48 Rideau St., Ottawa 2, Ont.)

5–9. International Rorschach Soc., 5th congr., Fribourg-en-Brisgau, Germany. (A. Friedemann, Chemin des Pêcheurs 6, Bienne, Switzerland)

6–10. Occupational Medicine and Toxicology, 3rd Inter-American conf., Miami, Fla. (W. B. Deichmann, School of Medicine, Univ. of Miami, Coral Gables, Fla.)

6–12. Atmospheric Ozone and General Circulation, symp., Arosa, Switzerland. (H. U. Duetsch, 20 Carl Spittelerstrasse, Zürich 53, Switzerland)

6–12. Chemical and Thermodynamic Properties at High Temperatures, symp., Montreal, Canada. (N. F. H. Bright, Natl. Research Council, Ottawa, Canada)

6–12. International Congr. of Pure and Applied Chemistry, 18th, Montreal, Canada. (L. Marion, Natl. Research Council, Ottawa 2, Canada)

7–9. Guidance and Navigation Conf., American Rocket Soc., Palo Alto, Calif. (J. J. Harford, ARS, 500 Fifth Ave., New York, N.Y.)

7–9. International Committee of Electro-Chemical Thermodynamics and Kinetics, 13th meeting, Montreal, Canada. (N. Ibl, Eidg. Technische Hochschule, Laboratorium für Physikalische und Elektrochemie, Universitätsstrasse 6, Zürich 6, Switzerland)

7–9. Space Age Astronomy, intern. symp., Pasadena, Calif. (D. W. Douglas, Jr., Douglas Aircraft Co., Inc., Santa Monica, Calif.)

7–10. National Medical Assoc., New York, N.Y. (J. T. Givens, 1108 Church St., Norfolk, Va.)

7–11. High Temperature Chemistry and Thermodynamics, symp., Montreal, Canada. (L. Brewer, Dept. of Chemistry, Univ. of California, Berkeley)

7–11. Seminar on Fast and Intermediate Reactors, International Atomic Energy Agency, Vienna, Austria. (IAEA, 11 Kärtner Ring, Vienna 1)

8–11. Poultry Science Assoc., State College, Pa. (C. B. Ryan, Texas A & M College, College Station)

8–16. Society of Protozoologists, Prague, Czechoslovakia. (N. D. Levine, College of Veterinary Medicine, Univ. of Illinois, Urbana)

10–16. International Congr. of Biochemistry, 5th, Moscow, U.S.S.R. (N. M. Sissakian, Leninsky prospekt, 33, Moscow, B-71)

10–16. International Union of Biochemistry, 4th general assembly, Moscow, U.S.S.R. (R. H. S. Thompson, IUB, Dept. of Chemical Pathology, Guy's Hospital Medical School, London, S.E.1, England)

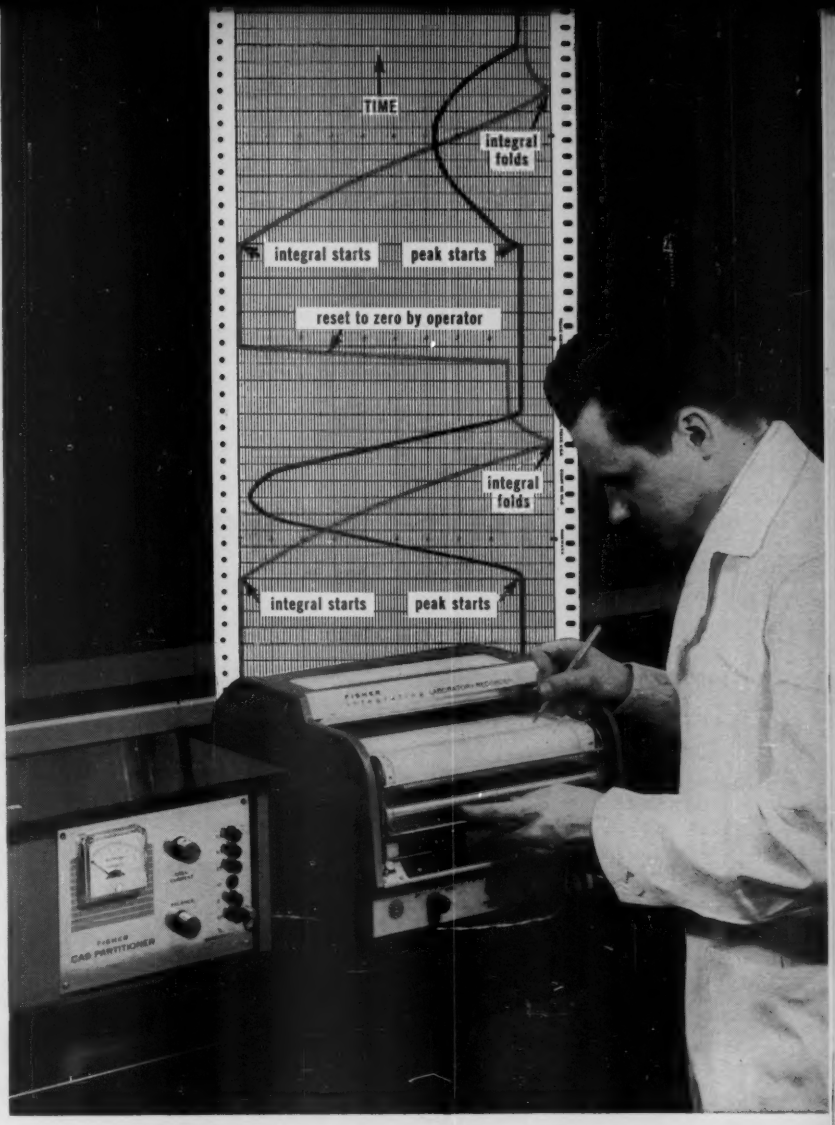
12–19. Fast Reactions, summer school, Cambridge, England. (Secretary of the Summer School, Dept. of Physical Chemistry, Lensfield Road, Cambridge)

13–18. Microchemical Techniques, intern. symp., University Park, Pa. (H. J. Francis, Jr., Pennsalt Chemical Corp., P.O. Box 4388, Chestnut Hill Post Office, Philadelphia 18, Pa.)

13–18. Theoretical Aspects of Magnetohydrodynamics, seminar, University Park, Pa. (Conference Center, Pennsylvania State Univ., University Park)

13–19. International Assoc. of Applied Psychology, 14th congr., Copenhagen, Denmark. (Congress Secretariat, 19 Sankt Pederstraede, Copenhagen K.)

13–19. Training for Research in the Processes of Vision, 1st intern. conf., Rochester, N.Y. (Office of Public Information, River Campus Station, Rochester)



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14–17. Calorimetry Conf., intern., Ottawa, Canada. (J. E. Kunzler, Bell Telephone Laboratories, Murray Hill, N.J.)

14–19. International Medical Conf. on Mental Retardation, 2nd, Vienna, Austria. (Miss E. Langer, Div. of Maternal and Child Health, State House, Augusta, Maine)

14–19. Symposium on Radiation, Vienna, Austria. (World Meteorological Organization, 1 Avenue de la Paix, Geneva, Switzerland)

14–25. Israel Medical Assoc., 5th world assembly, Jerusalem, Israel. (Beth-Harofeh, 1 Heffman St., Tel-Aviv, Israel)

14–26. Plant Pathology, conf., Lafayette, Ind. (J. F. Schafer, Dept. of Botany and Plant Pathology, Purdue Univ., Lafayette)

14–26. World Eucalyptus Conf., 2nd, São Paulo, Brazil. (Intern. Agency Liaison Branch, Office of the Director General, Food and Agriculture Organization, Viale delle Terme di Caracalla, Rome, Italy)

15–17. International Assoc. of Milk and Food Sanitarians, Jekyll Island, Ga. (H. L. Thomasson, P.O. Box 437, Shelbyville, Ind.)

15–18. Technical Assoc. of the Pulp and Paper Industry, 12th testing conf., Montreal, Canada. (TAPPI, 155 E. 44 St., New York 16)

15–24. International Astronomical Union, 11th general assembly, Berkeley, Calif. (D. H. Sadler, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex, England)

16–18. Hypersonics Conf., intern., Cambridge, Mass. (J. J. Harford, American Rocket Soc., 500 Fifth Ave., New York, N.Y.)

18–21. Association of American Geographers, East Lansing, Mich. (M. F. Burrill, 1785 Massachusetts Ave., NW, Washington 6)

19–30. Agricultural Economists, 11th intern. conf., Cuernavaca, Mexico. (J. Ackerman, Farm Foundation, 600 S. Michigan Ave., Chicago, Ill.)

20–23. International Ergonomics Assoc., 1st congr., Stockholm, Sweden. (T. Olson, Dept. of Industrial Physiology, G.C.I. Lidingövägen 1, Stockholm)

20–24. American Veterinary Medical Assoc., Detroit, Mich. (H. E. Kingman, AVMA, 600 S. Michigan Ave., Chicago 5, Ill.)

21–23. International Hypersonics Conf., Cambridge, Mass. (F. Ridell, Avco Research Laboratory, 301 Lowell St., Wilmington, Mass.)

21–24. Biological Photographic Assoc., Chicago, Ill. (Mrs. J. W. Crouch, Box 1668, Grand Central P.O., New York 17)

21–24. International Conf. on Photoconductivity, Ithaca, N.Y. (E. Burstein, Dept. of Physics, Univ. of Pennsylvania, Philadelphia)

21–26. International Congr. of Psychotherapy, 5th, Vienna, Austria. (W. Spiel, Lazarettg. 14, Vienna 9)

21–26. World Traffic Engineering Conf., Washington, D.C. (Intern. Road Federation, 1023 Washington Bldg., Washington 5)

21–27. International Assoc. of Dental Students, congr., London, England. (D. H. Clark, Royal Dental Hospital, Leicester Sq., London, W.C.2)

21–31. United Nations Conf. on New Sources of Energy, Rome, Italy. (United Nations, New York, N.Y.)

21–2. International Congr. of Practical Medicine, Merano, Italy. (Bundesärtztekammer, 1 Hädenkampfstrasse, Cologne, Germany)

21–6. Pacific Science Congr., 10th, Honolulu, Hawaii. (Secretary General, 10th Pacific Science Congr., Bishop Museum, Honolulu)

22–25. International Pharmacological Meeting, 1st, Stockholm, Sweden. (A. Wretlind, Karolinska Institutet, Stockholm 60)

22–30. International Conf. on Protozoology, Prague, Czechoslovakia. (N. D. Levine, College of Veterinary Medicine, Univ. of Illinois, Urbana)

23–25. Gas Dynamics, symp., biennial, Evanston, Ill. (J. J. Harford, American Rocket Soc., 500 Fifth Ave., New York, N.Y.)

23–26. Electron Microscope Soc. of America, Pittsburgh, Pa. (Miss M. L. Rollins, Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 19,687, New Orleans 19, La.)

23–26. Institute of Management Sciences, 8th annual intern., Brussels, Belgium. (W. Smith, Inst. of Science and Technology, Univ. of Michigan, Ann Arbor)

(See issue of 16 June for comprehensive list)

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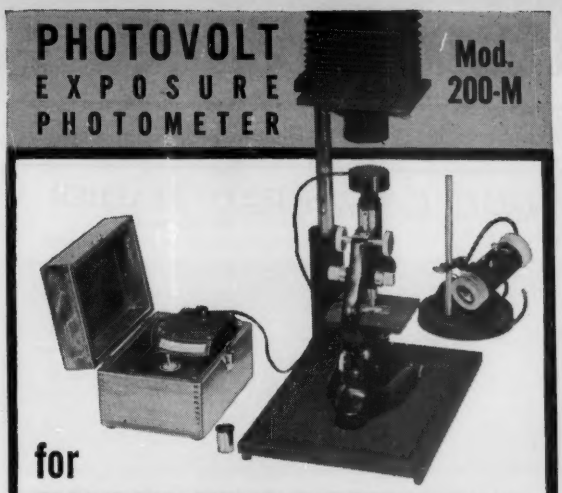

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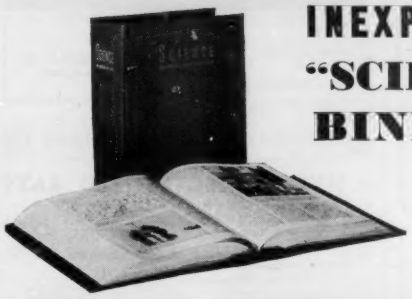

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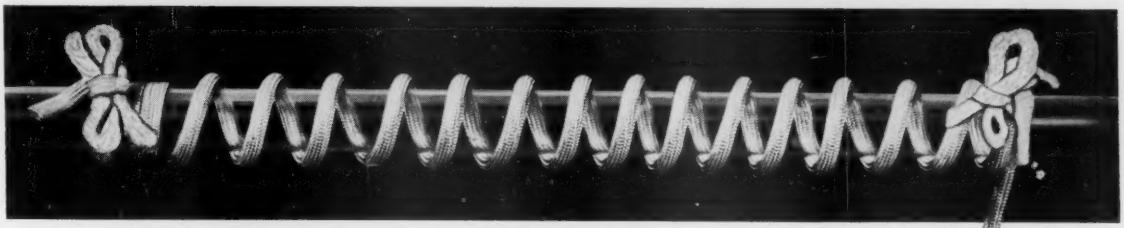

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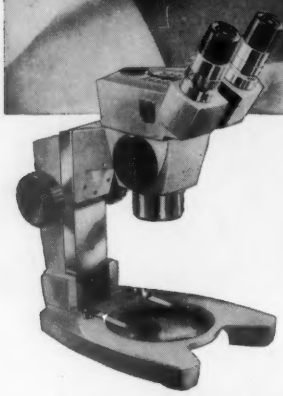

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